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花葯培養引發之水稻遺傳變異[1]

黃眞生　蔡新聲　陳治官[2]

摘要：水稻品種臺農67號由花葯培養產生的綠苗（AC_1S_0）113株中，有54.0%是四倍體及單倍體；有44.2%是二倍體：包括38.9%的正常植株，3.5%稔性降低，1.8%有粒型、葉型及葉綠素之突變。另有1.8%未抽穗無法鑑定。AC_1S_0 個體內也有低頻度的遺傳變異發生。52個 AC_1S_1 系統中有5.8%顯示低產，其餘均與原品種臺農67號產量相似。系統內個體的結實率分離及降低使穗重減輕，因而引起低產。AC_1S_1 系統除了結實率有突變外，株高、粒型、芒也有突變發生。共有69.8%的 AC_1S_1 系統保持與原品種臺農67號同樣之性狀。

花葯培養是目前可用於作物品種改良之生物技術[12]。此技術不但有縮短育種年限之功效，也可用於節省育種圃的面積及室外勞力。然花葯培養是否使其後代產生變異或何種變異，程度如何，均需吾人預先明瞭。

水稻的標誌基因經花葯培養仍然以正常的遺傳法則遺傳[3]，且使用 F_1 花葯培養之後代做連鎖遺傳分析，結果與 F_2 所得者相互吻合[1,2]。此似表示水稻花葯培養後代有相當高的遺傳穩定性，以致有人推薦花葯培養爲遺傳分析之新手段[1]。另一方面水稻經花葯培養後發現有矮性、不稔性等變異[6,8,9,10]，只有⅔的花葯二倍體是同型結合，其他⅓携有同型或異型結合的突變基因[8]。Calrose 76 經花葯培養後不但產生不稔性、大粒、矮性等突變體，也提高糙米的蛋白質含量，且有84%之系統與原品種有同樣的產量[9,10]。臺中65號花葯培養品系之產量與期作有顯著的交感效應[7]。

臺農67號爲本省目前的主要水稻品種，大多數育種材料均以此品種爲主要遺傳背景，於此品種所得的任何資料將有助於育種工作。筆者得到此品種的花葯培養綠色植物 113株，以此爲材料研究水稻純系品種經花葯培養後可能產生的遺傳變異，所得結果將報告於下。

材料及方法

本所組織培養室使用改良式 N_6 培養基[4]，與稻作室合作進行應用花葯培養的水稻品種改良工作。爲此育種計畫的對照，該室培養多數臺農67號之花粉植株，取其中 113株於一般水田栽種，即花葯培養第一代或 AC_1S_0 個體。在此世代仔細觀察每個體的形態特性，並依照外表特性分類爲單倍體，二倍體及多倍體。當代收穫結種子個體53個，其餘不結實個體則予淘汰。收穫種子以系統繁殖下一代，即 AC_1S_1 共53系統，另以未經花葯培養的臺農67號系統15個爲對照。每系統有45株，其中20株爲混合收穫後估計稻穀產量之用，10株，爲個體調查之用。調查項目除20株產量之外，有一株穗數、穗長、穗重、一穗粒數、千粒重、結實率、株高及其他可能之突變性狀。

花葯培養後各世代之代號尚無統一之命名制度，本試驗建議採用 AC_1, AC_2, ………代表花葯培養次數，S_0, S_1, ………代表培養後自交之次數。

1.臺灣省農業試驗所　研究報告第 1227 號。本研究承行政院農業委員會的經費補助（計畫號碼74農建—4.1—產植—46）及林永信先生之協助，特此申謝。

2.臺灣省農業試驗所研究員、研究員及助理研究員。臺灣省　臺中縣　峰霧鄉。

結果及討論

花葯培養第一代個體之變異

臺農67號花葯培養 AC_1S_0 秧苗，因陸陸續續從試管移出，以致抽穗期極是不整齊。有的個體或一個癒傷組織長出之營養系，只有一穗已抽穗開花，而其他穗延後2、3星期才抽出。由試管先移出的秧苗常有較長之秧苗期，有的延遲一個月以上，故部分秧苗在苗床先行花芽分化，成爲老秧而抽穗不整齊。此現象在 AC_1S_0 特別嚴重。有一個 AC_1S_0 個體下葉是縞葉，但上葉却正常；另有一株整株形態顯示標準的單倍體，但部分的穗却有半結實之現象。按正常單倍體不可能有如此之結實率。繁殖其種子，長出之後代却顯出標準的二倍體。故 AC_1S_0 個體在發育過程中，其少部分細胞的遺傳構造包括染色體之數目會隨生長而變化；以致下葉是縞葉上葉却是正常，或內外穎是單倍，但雌雄蕊却是二倍體。

總共113株綠苗中，有56株（49.5%）是單倍體，50株（44.2%）雙倍體，2株（1.8%）顯示四倍體之形態特徵，3株（2.6%）爲單倍及雙倍的混倍體（Mixoploid），剩餘2株（1.8%）未抽穗（表1）。50株雙倍體中有44株（38.9%）外型正常，3株半不稔，1株全不稔，1株小粒突變體，另一株是縞葉和窄葉的突變體（表1）。

表1. 臺農67號花藥培養第一代（AC_1S_0）個體之變異（1984一期作）

Table 1. Variation of AC_1S_0 plants of Tainung 67 from anther culture (1st crop, 1984).

2n				n	n+2n	4n	未抽穗 Unheaded	計 Total
正常 Normal	半不稔 Semisterile	全不稔 Compl. sterile	突變體 Mutant					
44	3	1	2	56	3	2	2	113
38.9	2.6	0.9	1.8	49.5	2.7	1.8	1.8	100(%)

小粒或具有縞葉及窄葉。

Small grain or varigated and narrow-leafed.

水稻花葯培養已有許多國內外之報告 (2,3,4,6,8,9,10)，均認爲雙倍及四倍體是由花粉癒傷組織單倍體細胞加倍而來者。本試驗 AC_1S_0 個體中有約50%是單倍體，而約45%是雙倍體（表1）。育種家的希望是雙倍體有更高的頻度，而單倍體則愈少愈好。因爲單倍體不結實，無種子可收，必須加倍染色體成二倍體才有用途，而加倍染色體所花的時間必然會抵消掉花葯培養所節省的育種年限。故如何利用秋水仙精於試管內加倍染色體，以提高雙倍體秧苗的頻度，乃當前之急務。

以上花葯培養所產生的第一代 AC_1S_0 個體有如下之特性。（1）個體間染色體數目有變化，尤其是各級倍數體之出現，（2）個體間性狀可能有大幅的變異，即突變，（3）AC_1S_0 個體內有遺傳變異，包括染色體數目及基因之變異以及生理作用不穩定或後生的遺傳變異（Epigenetic change）。故於 AC_1S_0 不宜做選拔，只能做不良基因型之淘汰。

花葯培養對其後代系統產量之影響：

臺農67號 AC_1S_1 系統的產量與未經花葯培養的臺農67號系統比較有少部分的差異，即產量低的系統數目較多。例如 TNG 67 AC_1S_1 系統內，20株產量低於 300g 者有三系統，而 TNG 67 (CK) 內則全無（表2）。因沒設重複，不能做確定的測驗。但最低產系統的產量只有臺農67號 CK 的一半，產量有如此大之差異是不可能不顯著的。AC_1S_1 系統除了有5.8%的系統顯示低產之外，其餘系統之產量均與對照種臺農67號系統相似；產量變異之範圍也相同（表2）。按前述少部分系統的產量降低是產量構成因素發生變化之關係。如後述花葯培養後代的結實率及穗重容易發生變化，以致產量降低。

表2. 臺農67號花藥培養第二代（AC_1S_1）系統稻穀產量之分佈

Table 2. Distsibution of grain yields of Tainung 67 AC_1S_1 lines from anther culture.

(400g/20株=4,464kg/ha, 1984-II)

產量 (g/20pl.) Yield	150	200	250	300	350	400	450	500	計（系統數） Total (line No.)
TNG 67 AC_1S_1	1 (2)	1 (2)	1 (2)	10 (20)	15 (29)	14 (27)	8 (16)	2 (2)	52 (100%)
TNG 67 (CK)				3 (20)	5 (33)	2 (13)	3 (20)	2 (13)	15 (100%)

TNG=Tainung

花葯培養對其後代系統農藝性狀之影響

AC_1S_1 系統7個農藝性狀的變量分析如表3所示。以系統內變量之平均為機差做 F 測驗，結果有不少性狀連臺農67號系統間的差異也顯著（表3）。此是否臺農67號系統間的確存有遺傳變異，或系統內土壤差異小，以致機差的估計過小，則不得而知。故特使用臺農67號系統間的變量為機差做 F 測驗，以便測出花藥培養所引起之遺傳變異，即：

$$\frac{\text{TNG67}AC_1S_1\ \text{系統間變量}}{\text{TNG67 系統間變量}} = \frac{\sigma^2{}_e+\sigma^2{}_{TNG67}+\sigma^2{}_{AC}}{\sigma^2{}_e+\sigma^2{}_{TNG67}} = \text{F值} \rightarrow \text{測驗 AC 之遺傳變量}$$

結果穗重，結實率及株高有極顯著的花藥培養遺傳變異，穗長及一穗粒數也呈顯著（表3）。

穗重與結實率是互相有連帶關係的，即結實率低，穗重亦低。故系統內有些個體的結實率降低，不但使穗重變量顯著增加，也使該系統的產量降低。臺農67號 AC_1S_1 有10個系統，其平均結實率比臺農67號 CK 任何系統低，而有5個系統其結實率變異係數比臺農67號高（表4）。例如 AC_1S_1 6963 分離出結實與半結實個體各10株及33株，而20株產量只有 145g，幾乎為臺農67號 CK 的一半

表3. 臺農67號花藥培養第二代（AC_1S_1）系統各農藝性狀之變量分析表（民國73年二期）

Table 3. Variance analysis for agronomic traits of Tainung 67 AC_1S_1 lines from anther culture (1984-II).

變因 Source of varietion	自由度 Degree of freedom	均方 Mean square						
		一株穗數 Panicle No. /plant	穗長 Panicle length	穗重 Panicle wgt.	一穗粒數 Grain No. /panicle	千粒重 1,000 grain wgt.	結實率 Seedset (%)	株高 Plant height
全系統間 Among all lines	66	16.568**	1.873**	0.561**	623.25**	7.530**	783.11**	129.02**
AC_1S_1 系統間 Among AC_1S_1 lines	51	17.097**	1.630**	0.681**	634.89**	8.158**	852.52**	143.04**
TNG 67 系統間 Among TNG 67 lines	14	13.168**	0.728	0.161	292.62	5.552**	191.76**	29.71**
AC_1S_1 系統對 TNG 67系統 AC_1S_1 vs. TNG 67	1	37.163**	30.284**	0.045	4,856.46**	3.187	5,568.18**	549.50**
機差 Error	603	5.395	0.601	0.104	184.14	1.047	61.62	11.75
變量 (AC_1S_1)/變量 (TNG 67) Variance (AC_1S_1)/Variance (TNG 67)		1.298n. s.	2.239*	4.230**	2.170*	1.469n. s.	4.446**	4.982**

TNG=Tainung

表4. 臺農67號花藥培養第二代（AC_1S_1）系統平均結實率及變異系數之分佈（民73年二期）

Table 4. Average seedset percentage and its coefficient of variation of Tainung 67 AC_1S_1 lines from anther culture (1934, second crop).

稔實率（%） Seedset (%)	25	35	45	55	65	75	85	計 Total	結實率 C. V. (%) Seedset % C. V. 5	15	25
TNG 67 AC_1S_1	1		3	6	24	17	2	53	31	15	5
TNG 67 CK					4	10	1	15	12	3	

TNG＝Tainung

或不到。AC_1S_1 6926 結實率平均只有49.4%又呈連續性變異，其產量只有 248g。其他結實率低而呈連續性或不連續性變異的系統有 AC_1S_1 6927, 6955, 6965 及6968。以上花藥培養引起後代結實率之降低，以致穗重、產量減少是勿庸置疑之結論。不稔性或半不稔性對育種有某程度的麻煩，但不致於構成障礙。因爲不稔或半不稔個體必然會遭自然淘汰，也不難於人工選拔時給予淘汰。

另一個性狀在 TNG 67 AC_1C_1 系統間變量與 TNG 67 CK 系統間變量有極顯著差異者是株高（表3）。株高的遺傳力與結實率同樣屬於較高的一類。TNG 67 CK 的系統平均株高最高是96.7 cm，最低 90.5cm。然而 AC_1S_1 系統最高者有 103.9cm (6924) ，而最低的只有83.8cm (6942) 。兩者株高的分佈亦如圖1。很明顯的 AC_1S_1 的株高往高低兩方向增加及減少。數量性狀的突變往正負兩方向發生，在放射線誘變試驗已有不少的報告佐證。按水稻體細胞的組織培養會引起後代的基因突變已是確立的定論[5,11]。花藥培養也同樣引起相似之突變，也許兩者發自同樣的機制。

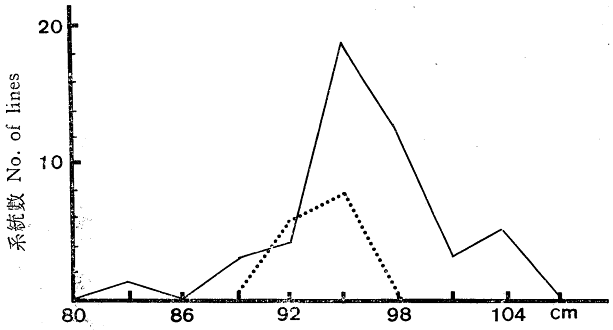

圖1. 臺農67號 AC_1S_1 系統平均株高之分佈（臺農67號 CK 虛線，民國73—Ⅱ）。

Fig. 1. Distribution of average plant heights of Tainung 67 AC_1S_1 lines and Tainung 67 CK (broken line) as the control (1984 second crop).

除上述性狀之外，粒型、芒也有花藥培養所引發之遺傳變異，雖然變量分析在千粒重未測得顯著的 σ^2_{AC}。爲進一步明瞭 σ^2_{AC} 之存在，特選 AC_1S_1 系統內有遺傳變異或可能有遺傳變異的系統，每系統取具代表性者2～3株，於民國74年一期參加後裔檢驗，以便於 AC_1S_2 進一步觀察其遺傳變異。經過花藥培養而尚正常的臺農67號及臺農67號 CK 兩者爲對照。

花藥培養引發之遺傳變異，常有多發性之現象。例如 AC_1S_1 6942，其結實率平均有53.0%而成連續性變異；株高平均只有 83.8cm 相當整齊，比正常者矮約 10cm ；同時小粒型及正常粒型成約1比1之分離。AC_1S_1 6963 結實率低而有分離現象外，粒型變大，即千粒重有 25.1g。AC_1S_1 6968

分離出有芒半不稔個體，同時粒型變大（千粒重 25.3g）。總共53個 AC_1S_1 系統中有16系統具有遺傳變異或可能具有遺傳變異，變異性狀包括稔性，株高、粒型、芒。剩餘37個 AC_1S_1 系統即69.8%顯示正常與原臺農67號相同。

花藥培養引起之遺傳變異對育種之冲擊

以上試驗結果確認水稻花藥的體外培養使其後代個體或系統產生各種遺傳變異，包括染色體數目及基因的突變。這些變異與體細胞培養所引起之突變[5,11]，可能源於同一機制。植物有70%之重複DNA，基因不穩定[12]，易受環境因素之影響產生突變，這是動物所少有的[12]。誘變的因素包括自然或人工的放射線，引變化學藥品，培養液或培養基之營養條件等。植物無動物的機動遷移能力，遇到不良環境時無法以遷移來逃避，只好靠不穩定的基因組成來改變其本身的性狀，以便適應於環境[12]。

作物育種的第一步驟是增加遺傳變異，以便擴大選拔之基因型範圍。引種及雜交乃是常用的增加新基因型之手段。若花藥培養的對象是雜種，所產生的花粉後代除了原有的雜種遺傳變異之外也有花藥培養所引起之突變，增加選拔之基因型範圍，對育種而言並無不利之處。問題是基因的重組是否會受花藥培養擾亂。如前述，水稻標誌基因不受花藥培養之影響，仍然以正常的遺傳法則遺傳至花粉後代[3]。由花粉後代估計之重組價與傳統方法估計者互相吻合[1,2]。故到目前爲止，尙未發現花藥培養對育種有不利之證據。

花藥培養的另一個值得重視的產物是同源四倍體。水稻四倍體的育種至今還在理論之階段，主要瓶頸是材料之來源。收集花藥培養引發的四倍體，累積四倍體之育種材料，將有助於開發水稻育種的新途徑。

前述花藥培養產生的後代，有54%是單倍體。按單倍體只有單量的基因，基因的表現單純，易由表現型來推斷基因型，便於性狀之測驗及篩選。但試管外單倍體的染色體加倍，需要多花時間，且成功率有限，以至花藥培養的優點之一即縮短育種年限，必然會受到打折扣。故最好能發展一種技術，以便於癒傷組織做各種性狀例如抗病抗蟲之測驗及篩選，並於試管內加倍癒傷組織細胞或花粉植物的染色體，如此不但能保持縮短育種年限之優點，也有可能節省特性檢驗所需之勞力及時間。

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Genetic Changes of Rice Variety Induced by Anther Culture[1]

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Summary

Among 113 anther-derived green plants (AC_1S_0) of rice variety Tainung 67, 54.0% were haploid, tetraploid and mixoploid; 44.2% were diploid, including 38.9% of the normal plants, 3.5% of low seedset plants and 1.8% of mutated types in the grain size, chlorophyll and leaf shape. The remaining 1.8% did not produce panicle at harvest. There was a low frequency of genetic change occurred within an individual AC_1S_0 tiller. All AC_1S_1 lines gave an yield similar to those of Tainung 67 lines, except 5.8% that yielded distinctly lower. The low yield of these lines was caused by the segregation and lowering of seedset percentage and the panicle weight. In addition to the seedset percentage, mutations in the plant height, grain size and awn also appeared in the AC_1S_1 lines, of which 69.8% retained the characteristics of the original Tainung 67.

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秈稻烹調與食用品質及穀粒性狀之遺傳[1]

郭益全　劉　清　張德梅　謝順景[2]

摘要：以包括親本與正反交組合之5×5秈稻全互交組合研究秈稻烹調與食用品質及穀粒大小等7個性狀之遺傳。被評估7個品質性狀之親本間的遺傳變異極大，此種變異係由累加性與顯性效應所引起。除膠體硬度外，各性狀之累加性效應均遠大於顯性效應。各性狀之遺傳率值均很高，强調表現型變異主由累加性效應控制。鹼質擴散度、顆粒澱粉含量、膠體硬度、粒寬及粒厚等性狀有細胞質效應。經由迴歸與變方分析估得7個被評估性狀之顯性程度除膠體硬度為完全顯性外，餘均為部分或不完全顯性。其經迴歸圖及親本顯性次序估算判定低鹼質擴散度、低蛋白質含量、高顆粒澱粉含量、高膠體硬度、長粒、寬粒及厚粒為顯性。正負等位基因之頻度烹調與食用品質性狀相等，穀粒大小性狀不等。鹼質擴散度、蛋白質含量及顆粒澱粉含量之顯性因子總數與隱性因子總數相等，膠體硬度及穀粒大小等4性狀則隱性因子總數多於顯性因子數。

本省栽培之水稻品種可大別為秈粳兩型，兩型對外界環境之反應，產量潛能及米質特性殊有不同。傳統之秈稻品種概為粒形短圓及顆粒澱粉含量高之臺灣在來品種，其對主要病蟲害之抗性與產量潛能均差，煮成之米飯質地粗硬而乾鬆。及至長粒形半矮性秈稻推出，因此類品種對若干重要病蟲害具抵抗性，且半矮性之高產潛能又被肯定，致至1980年本省稻作面積有一半以上是栽種半矮性秈稻或有半矮性秈稻生殖質親緣的品種[9]。按此半矮性長粒秈稻比粳稻具有更優良的特性[8]，栽培面積理應大幅增加，然據黃[8,9]之綜論，秈稻之栽培面積却逐年急速下降，其重要性有落得與糯稻相近之慮[9]。諸多研究[2,5,10]與綜論[3,4,8,9]指出長秈稻之容重量與稻米品質未臻理想是秈稻產銷上兩個亟待克服之大問題。

稻穀容重量與穀粒長成極顯著之負相關[2,8,10]，穀粒長又與碾糙率[8,10]及白米率[8]成極顯著之負相關。亦即半矮性長粒形秈稻之穀粒長不僅導致長秈稻容重量之低下，亦影響到若干碾米品質。黃[8]為文揭櫫晚近推廣秈稻之高產潛力似由於半矮性，而非長粒形之故，堀末[12]亦建議國內秈稻育種應縮短半矮性長秈稻之粒長。凡此種種顯示半矮性秈稻穀粒之長短實為國內現階段秈稻育種方向上應確切加以檢討之目標性狀之一。

白米膠化溫度（gelatinization temperature）、蛋白質含量、顆粒澱粉含量及膠體硬度（gel consistence）之測定為目前主要秈米產銷國家用為烹調與食用品質合意與否的主要判定依據。膠化溫度與膠體硬度是米粒澱粉之兩種物理特性；蛋白質與顆粒澱粉兩者是為米粒之重要內含成份。研究顯示米粒之顆粒澱粉含量為影響飯粒黏著度（cohesiveness）、柔軟性（tenderness）、色澤及光澤度（gloss）等風味品評因子之最主要因素[24,26,27,28,29,30,35,38]，膠體硬度得將高顆粒澱粉（25%以上）等級米之食用品質加以進一步之區分[14,37,38]，亦即顆粒澱粉含量及膠體硬度為關係秈米食用品質之兩個較主要之因素；而膠化溫度與蛋白質含量則為決定烹調品質之指標。然由於膠化溫度或蛋白質含

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量高之生米煮成熟飯時較低者須更長的時間和更多之水 [24,26,27,28,29]，且蛋白質含量與飯粒之色澤有關 [29,30,36]，故在一般煮飯條件下，膠化溫度與蛋白質含量之高低可能多少會影響到食用品質 [26,27]。綜合言之，白米之顆粒澱粉含量及膠體硬度雖爲決定秈米食用品質之兩個較重要的指標，但因爲膠化溫度及蛋白質含量等兩個支配白米烹調品質之性狀亦可能多少影響到食用品質，故考慮國內秈稻食用品質之育種問題時，膠化溫度、蛋白質與顆粒澱粉含量及膠體硬度等 4 性狀須一併檢討。

國際稻米市場以顆粒澱粉含量爲中至高之長秈稻爲主 [2,3,5]，故引入抗重要病蟲害之有用育種材料，亦概屬粒形細長且顆粒澱粉含量較高之品系（種）。而國內之秈稻育種目標，則爲粒形短圓及顆粒澱粉含量低者（煮成之米飯較具黏彈性），因之就擴大遺傳變異利用國外種源以育成適合國內市場需要品種（系）之前提下，應先究明食用品質及穀粒長短皆互異之雜交後代各目標性狀的遺傳行爲。

綜合以上之考慮，本研究乃選用膠化溫度、蛋白質與顆粒澱粉含量及膠體硬度互異且穀粒性狀亦殊有不同之秈稻行全互交，全面探討秈米烹調與食用品質及穀粒大小之遺傳，藉供省內秈稻育種工作之參考。

材料與方法

臺中秈 3 號、臺中秈10號、新竹矮脚尖、臺中秈 2 號及嘉農秈11號等 5 個秈稻品種被用爲全互交親本，其包括正反交之20個 F_1 及 5 親本於1982年 1 期作被栽植於農試所萬豐試驗農場。逢機完全區集設計（RCBD），4 重覆。每小試區栽植 5 行，每行12株，行株距 25×25cm。肥料用量 N、P_2O_5 及 K_2O 依次爲 90、40及 60kg/ha。適期收穫時每小區去邊行及頭尾株，以單株爲收穫單位，每小區計各收穫30株。日光乾燥後，每株分別脫粒，再以日製 Satake 脫殼機碾成糙米，測定10個糙米之長、寬及厚，取平均值爲各單株穀粒性狀之數據。每單株糙米再以日製 Kett 小樣品精米機分別碾成白米。每白米樣品除取部分仿 Little *et al.* [31] 鹼質擴散 (alkali digestion) 法判定其膠化溫度外，餘以 Udy 公司之旋風磨粉機（cyclone mill）磨成米粉。於 60°C 經48小時烘乾後，按 Juliano [25] 簡化白米顆粒澱粉含量定量法、Cagampang *et al.* [14] 膠體硬度測定法及 Udy 公司之 DBC (dye binding capacity) 蛋白質含量定量法分別測定各單株白米之顆粒澱粉含量、膠體硬度及蛋白質含量。每小區之數據爲各該區內30單株之平均。

本研究中全互交法之變方分析是依據 Hayman [20] 及張 [11] 修改前者所創對處理平方和劃分之公式進行各遺傳變因之平方和及均方之估算，各遺傳成分等之估算則按 Hayman [21] 之理論進行。廣義與狹義遺傳率及雜種優勢則均仿 Mather and Jinks [32] 之公式估計。

結　果

白米之膠化溫度、蛋白質與顆粒澱粉含量及膠體硬度等烹調與食用品質的評估性狀及穀粒性狀均爲稻米米粒之特性，而此米粒係由卵之兩個極核與一個精核融合成之一種 3n 組織(triploid tissue)。單株蛋白質及顆粒澱粉含量與膠體硬度之數據是下一世代種子混合樣品的測定值；而膠化溫度與穀粒性狀則是個別米粒之度量值。故由 F_1 稻株上 F_2 米粒目標性狀測定之後裔檢定可推論親本目標性狀之遺傳組成。

表 1 爲 5 個親本各該烹調與食用品質及穀粒性狀於1982年一期作之表現，此結果與宋 [3] 之數據大致相符。綜覽表 1 可知調查各性狀有明顯之遺傳變異性（genetical diversity）存在。在烹調與食用品質方面，鹼質擴散度之變域由臺中秈10號之5.7到嘉農秈11號之2.8；蛋白質含量之變域由新竹矮脚尖之 6.64%到臺中秈 2 號之 5.51%；顆粒澱粉含量之變域由嘉農秈11號之 27.7 %到臺中秈 3 號之 19.0%；膠體硬度之變域由臺中秈11號之 55.4mm 到嘉農秈11號之 29.5mm。至於穀粒性狀方面，臺中秈10號及 3 號與嘉農秈11號爲長粒形，新竹矮脚尖及臺中秈 3 號則屬短圓形。

由親本與正反交 F_1 後裔估得各烹調與食用品質及穀粒性狀之雜種優勢列於表 2，受測 7 個性狀

中僅顆粒澱粉含量及膠體硬度等兩個主要評估性狀有雜種優勢現象，而由各該雜種優勢値之符號指出高顆粒澱粉含量者爲顯性，膠體硬度食用品質方面則短的膠體展流爲顯性，餘鹼質擴散度、蛋白質含量及穀粒性狀等均未發現有雜親優勢現象存在。

表 1.五個秈稻品種之品質與穀粒性狀

Table 1. Quality and grain characteristics of five *indica* rice varieties.

Variety	Cooking and eating quality				Grain dimensions of brown rice		
	Alakli spreading score	Protein content (%)	Amylose content (%)	Gel consistence (mm)	Kernel length (mm)	Kernel width (mm)	Kernel thickness (mm)
Taichung Sen No. 10	5.7	6.49	19.2	55.4	6.2	2.3	1.8
Taichung Sen No. 3	5.3	6.55	19.0	44.5	6.7	2.2	1.8
Hsinchu Ai Chuen Chien	3.1	6.64	26.7	30.3	4.9	2.9	1.9
Taichung Sen No. 2	3.0	5.51	27.2	30.1	4.8	2.9	1.9
Chianung Sen No. 11	2.8	5.68	27.7	29.5	6.3	2.2	1.7

表 2.親本及F_1品質與穀粒性狀之平均及雜種優勢

Table 2. Parental and F_1 means and heteroses for quality and grain characterisitios.

Population	Cooking and eating quality				Grain dimensions of brown rice		
	Alkali spreading score	Protein content (%)	Amylose content (%)	Gel consistence (mm)	Kernel length (mm)	Kernel width (mm)	Kernel thickness (mm)
Parental mean	4.0	6.17	23.9	38.0	5.8	2.5	1.8
F_1 mean	3.8	5.99	27.1	33.1	5.7	2.6	1.8
Heteroses[1]	− 0.2ns	− 0.16ns	3.2**	− 4.9**	− 0.1ns	0.1ns	0.0ns

1 : $(\bar{X}_{F1}-\bar{X}_P)$.

** : Statistically significant at 1 % probability level.

ns : Nons-ignificant.

被調查7個品質性狀經藉 Hayman[20] 全互交表變方分析所得諸遺傳變因的初步描述如表 3，各品質性狀處理項下 a 變因皆極顯著，指出各參試親本間有相當大之遺傳變異存在；b 變因各性狀亦皆極顯著，表示本研究中親本各該有關性狀部分基因座上，顯性擔任相當重要之角色。7 個性狀中除穀粒長外，其餘之 b_1 變因均顯著，顯示這些性狀之顯性因子效應是單方向。7 個品質性狀中僅糙米粒長、寬及厚等 3 個穀粒性狀之 b_2 變因顯著，指出支配這些性狀之顯性基因在親本間之分布不均勻。各品質性狀 b_3 變因均極顯著，提示這些性狀具有顯性與累加性或顯性與顯性交感等特殊顯性效果。c 及 d 變因爲細胞質效應 (maternal effect) 之變異，由表 3 知 7 個品質性狀中有部分性狀存有細胞質效應。

表 3.秈稻品質與穀粒性狀之變方分析

Table 3. Analyses of variance for quality and grain characteristics in *indica* rice.

Source of variance	D. F.	Cooking and eating quality				Grain dimensions of brown rice		
		Alkali spreading score	Protein content	Amylose content	Gel consistence	Kernel length	Kernel width	Kernel thickness
Block	3	—	—	—	—	—	—	—
Treatment	24	**	**	**	**	**	**	**
a	4	**	**	**	**	**	**	**
b	10	**	**	**	**	**	**	**
b_1	1	**	**	**	**	ns	**	**
b_2	4	ns	ns	ns	ns	*	**	**
b_3	5	**	**	**	**	**	**	**
c	4	ns	ns	**	**	ns	*	ns
d	6	*	ns	**	*	ns	**	*
Error	72							
Total	99							

*, ** : Statistically significant at 5% and 1% probability levels, respectively.
ns : Non-significant.

表 4.秈稻品質與穀粒性狀之遺傳變異成分及其標準偏差

Table 4. Estimates of genetic components of variance and their standard deviation for quality and grain characteristics in *indica* rice.

Genetical component	Cooking and eating quality				Grain dimensions of brown rice		
	Alkali spreading score	Protein content	Amylose content	Gel consistence	Kernel length	Kernel width	Kernel thickness
D	2.007** ± 0.018	0.272** ± 0.011	19.824** ± 0.463	134.753** ± 14.895	0.239** ± 0.005	0.123** ± 0.001	0.0070** ± 0.0008
H_1	0.195** ± 0.048	0.085** ± 0.030	11.661** ± 1.250	149.636** ± 40.227	0.022* ± 0.002	0.013** ± 0.003	0.0014** ± 0.0002
H_2	0.193** ± 0.044	0.080** ± 0.027	11.808** ± 1.134	144.379** ± 36.486	0.019** ± 0.001	0.012** ± 0.003	0.0013** ± 0.0002
h^2	0.090** ± 0.030	0.074** ± 0.019	26.648** ± 0.766	61.164** ± 24.633	0.024** ± 0.009	0.015** ± 0.002	0.0030** ± 0.0001
F	0.061ns ± 0.045	− 0.024ns ± 0.628	1.214ns ± 1.156	28.859ns ± 37.209	0.092** ± 0.013	0.011** ± 0.003	0.0007** ± 0.0002
E	0.006ns ± 0.007	0.015** ± 0.005	0.062ns ± 0.189	0.177ns ± 6.081	0.003ns ± 0.002	0.001ns ± 0.001	0.0002ns ± 0.0003
D-H_1	1.813** ± 0.043	0.187** ± 0.027	8.163** ± 1.111	− 14.883ns ± 35.749	0.217** ± 0.013	0.110** ± 0.003	0.0056** ± 0.0020

*, ** : Statistically significant at 5% and 1% probability levels, respectively.
ns : Non-significant.

親本間 (W_r-V_r) 值之純質性測驗 (homogeneous test) 可測定試驗資料是否符合 Hayman [21] 之遺傳假說及是否可按其理論作目標性狀遺傳成分之進一步估計。當 (W_r-V_r) 純質時，則親本間 (W_r-V_r) 之差異不大，亦即各親本 (V_r, W_r) 點對序列變積依序列方而變異之迴歸直線之離差不大，亦即試驗資料能符合 Hayman [20] 之假說，能行各遺傳成分之進一步估算。本研究各品質性狀資料經是項純質性測驗均不顯著 (數據未列出)，故應用該理論估出 7 品質性狀之各該遺傳成分如表 4，而藉諸遺傳成分估出之各品質性狀之遺傳系統值則列於表 5。

表 5. 秈稻品質與穀粒性狀之遺傳系統

Table 5. Estimates of genetic systems for quality and grain characteristics in *indica* rice.

Estimate	Cooking and eating quality				Grain dimensions of brown rice		
	Alkali spreading score	Protein content	Amylose content	Gel onsistence	Kernel length	Kernel width	Kernel thickness
$(H_1/D)^{½}$							
By graphic	0.3225	0.6561	0.7710	1.0547	0.3048	0.3292	0.4598
By variances	0.3115	0.5580	0.7670	1.0538	0.3037	0.3276	0.4518
$H_2/4H_1$ (uv)	0.2476	0.2361	0.2489	0.2412	0.2158	0.2329	0.2366
K_d/K_r	1.1031	0.8532	1.0832	1.2262	2.1220	1.3020	1.2515
h^2/H_2	0.4669	0.9223	2.2956	0.4236	1.250	1.2460	2.2464
Heritability (%)							
Broad-sense	99.45	91.94	99.50	99.81	99.03	99.92	99.44
Narrow-sense	94.76	81.15	75.89	60.51	97.60	94.78	88.76
r of $(W_r+V_r)/Y_r$	0.991**	0.934*	−0.995**	0.982**	−0.905*	−0.790ns	−0.846ns
Order of dominance of parent	35412[a]	45132	45321	53421	21543	43512	43152
Order of parental performance	12345[a]	32154	54312	12345	25134	43152	34215

*, ** : Statistically significant at 5% and 1% probability levels, respectively.
ns : Non-significant.
[a] : Parent code : 1-Taichung Sen No. 10, 2-Taichung Sen No. 3, 3-Hsinchu Ai Chuen Chien, 4-Taichung Sen No. 2, 5-Chianung Sen No. 11.

稻米膠化溫度之測定方法有 Amylogroph determination 及質擴散度等兩法，而鹼質擴散度測定爲毋須昂貴設備且操作簡易之測定方法。本研究發現米粒鹼質擴散度之 D、H_1-H_2 及 h^2 等遺傳成分皆極顯著地異於零 (表 4)，指出累加性 (D) 與顯性 (H_1、H_2 及 h_2) 效應對控制米粒之膠化溫度很重要。$D-H_1$ 爲極顯著之正值，表示支配本性狀有關基因之累加性效應顯著地大於顯性效應，此可推論鹼質擴散度之遺傳率值很大，故與利用諸遺傳成份估得之高的廣狹義遺傳率值 (表 5) 相對應。本性狀之 F 值與零之差異不顯著，指出有關基因或無顯性效應，或爲每一基因座之顯隱等位基因平均分布於諸親本間，此結果印證全互交表變方分析初步描述遺傳變因時，提示目標性狀顯性基因是否均勻分布諸親本間之 b_2 變因 (表 3) 亦不顯著、$D-H_1$ 雖顯著異於零、顯性成分 (H_1、H_2 及 h_2) 顯著及平均顯性程度 $(H_1/D)^{1/2}$ 值介於 0 與 1 之間，故可綜合推定本性狀 F 與零差異不顯著應係有關每基因之諸顯隱等位基因平均分布於諸親本間，而非有關基因無顯性效應之故。

米粒鹼質擴散度之 H_1 與 H_2 值相當接近 (表 4)，$H_2/4H_1=0.2476$，接近 0.25 極限值，指出親本間正與負等位基因頻度相等。平均顯性程度 $(H_1/D)^{1/2}$ 值介於 0 與 1 之間 (表 5 及圖 1)，建

議控制米粒鹼質擴散度之基因呈部分或不完全顯性。親本中顯隱因子數比 $(K_d/K_r) \doteqdot 1$，因知供試 5 親本中有關本性狀之顯性因子數與隱性因子總數相等。控制本性狀顯性因子數之估值 $h^2/H_2=0.4669$ 顯示似無主效顯性因子存在。按當各顯性因子正負符號相異時，此值易低估，而當有關因子僅部分或無顯性時，此值則不易檢出(3)，有互補因子時也常低估(11)。

米粒鹼質擴散度親本均值 (Y_r) 與對應 W_r+V_r 值成極顯著之正相關（表 5），表示 W_r+V_r 值增加時，隱性因子數相對增加，亦即鹼質擴散度值增加，伴隨隱性因子數之增加，故知米粒鹼質擴散度值小者（負方向）爲顯性（圖 2）。推得本研究 5 個供試親本中，本性狀之顯性次序爲 35412（圖 1 及圖 2），而親本表現之次序則12345。

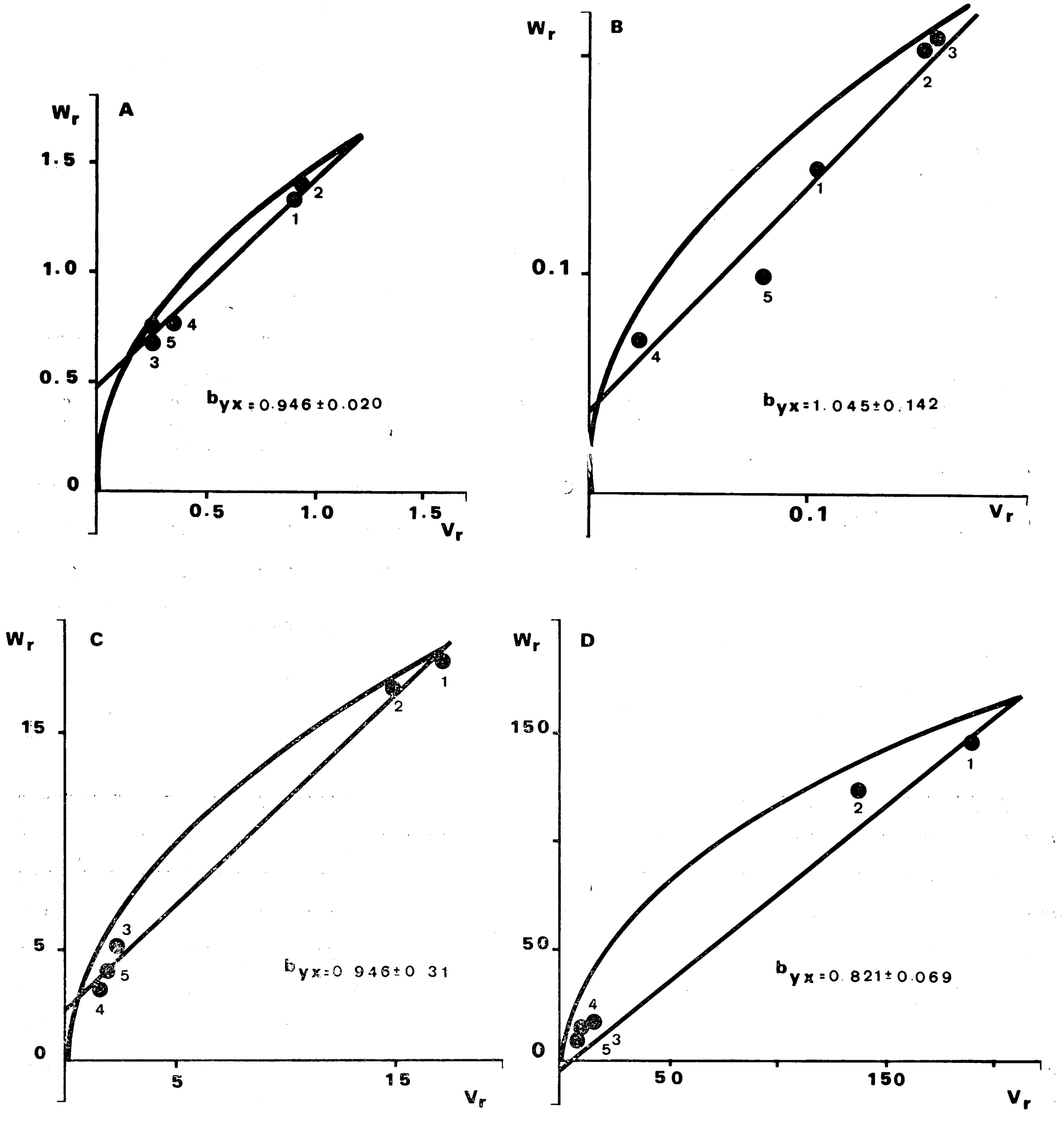

圖 1A-D. 鹼質擴散度、蛋白質含量、顆粒澱粉含量及膠體硬度之 W_r/V_r 圖。親本代號如表 5。

Figs. 1A-D. W_r/V_r graphs for alakli spreading score, protein content, amylose content and gel consistence, respectively.

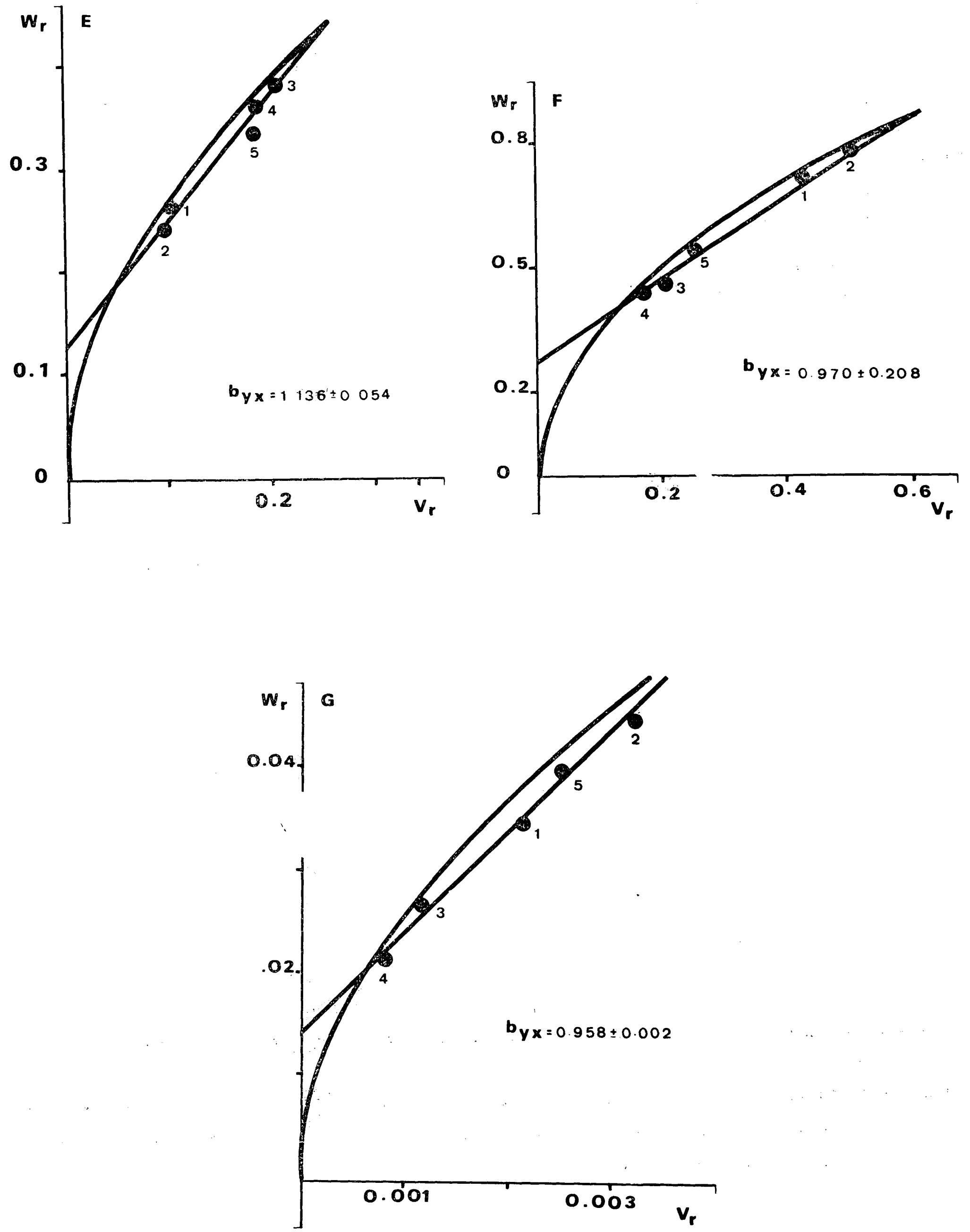

圖 1E-G. 穀粒長、寬及厚之 W_r/V_r 圖。親本代號如表5。

Figs. 1E-G. W_r/V_r graphs for grain length, grain width and grain thickness, respectively.

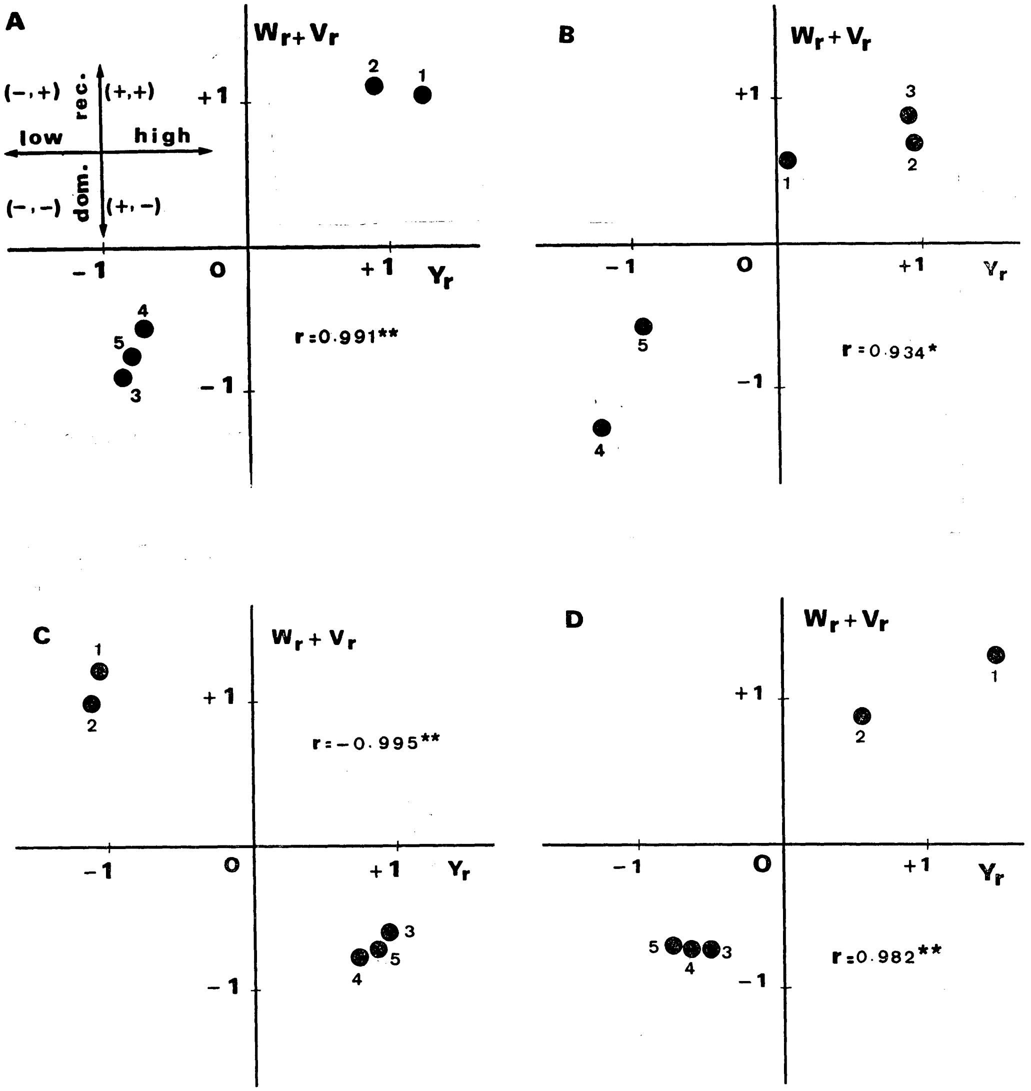

圖 2A–D. 鹼質擴散度、蛋白質含量、顆粒澱粉含量及膠體硬度 Y_r 與 W_r+V_r 之標準偏差圖・親本代號如表5。

Figs. 2A–D. Standardized deviation graphs between Y_r (parental performance) and W_r+V_r (order of dominance) for alkali spreading score, protein content, amylose content and gel consistence, respectively.

米粒蛋白質含量主爲白米營養品質，亦是稻米烹調品質性狀之一。研究數據顯示蛋白質含量與鹼質擴散度之遺傳成分模式極近似（表4），亦爲累加性與顯性效應皆顯著，且累加性效應顯著地大爲顯性效應。綜合有關數據推定蛋白質含量遺傳成份 F 值與零無差異，亦爲有關每基因之諸顯隱等位基因平均分布於諸親之故。H_1 與 H_2 成分亦相當近似（表4），$H_2/4H_1=0.2361\div0.25$（表5），即 $u=v=0.5$, $uv=0.25$，指出親本間正與負等位基因頻度相等。$1>(H_1/D)^{1/2}>0$，建議控制米粒蛋白質含量之基因呈部分或不完全顯性，參試親本之顯性因子與隱性因子數可能相等（$K_d/K_r=$

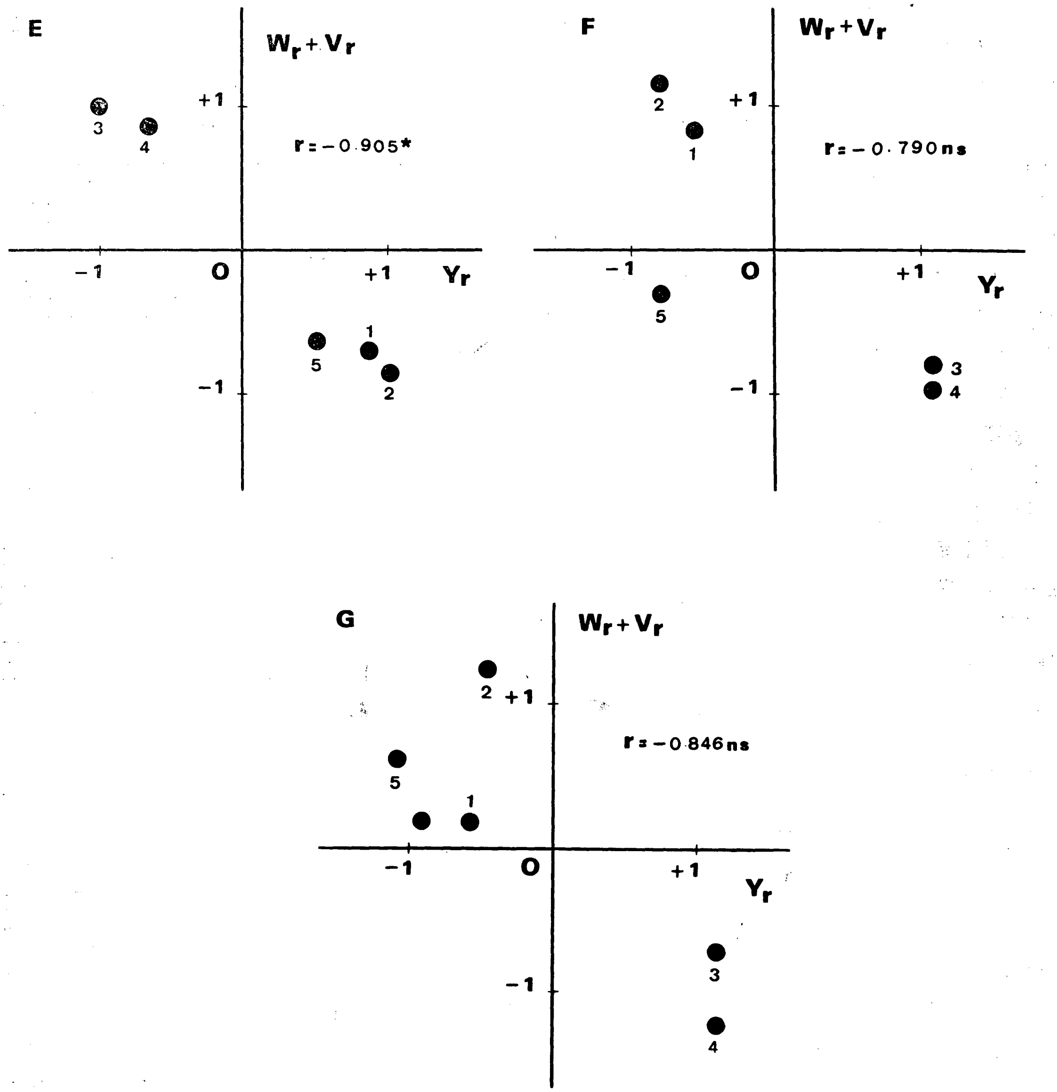

圖 2E-G. 穀粒長、寬及厚 Y_r 與 W_r+V_r 之標準偏差圖，親本代號如表 5。

Figs. 2E-G. Standardized deviation graphs between Y_r (parental performance) and W_r+V_r (order of dominance) for grain length, grain width and grainthickness, respectively.

0.8532≑1，表 5）。檢出之可能顯性主效因子爲一對（$h^2/H_2=0.9223≑1$），廣狹義遺傳率值均高，指出早世代選拔效果頗大。由蛋白質含量親本均值（Y_r）與對應 W_r+V_r 值成極顯著之正相關（表 5 及圖 2），及 W_r 依 V_r 之迴歸分析（圖 1），推得低蛋白質含量者爲顯性，親本顯性次序爲45132，親本表現次序爲32154。

長久以來米粒顆粒澱粉含量向被認爲係影響秈米食用品質最重要之因素，數據顯示顆粒澱粉含量之累加性效應（D）與顯性效應（H_1、H_2 及 h^2）均極顯著，指出兩者對米粒顆粒澱粉含量之表現至

爲重要，累加性效應似又較顯性效應爲大，此可由高的廣狹義遺傳率值及 $D-H_1$ 爲極顯著之正值來印證（表 4 及表 5）。H_1 成分與 H_2 成分相近，提供親本間正與負等位基因平均頻度是否相等之估值 $H_2/4H_1=0.2489 \doteqdot 0.25$，指出親本間有關顆粒澱粉含量正與負等位基因頻度相等。綜合 F 成分、b_2 變因及 $D-H_1$ 值及 h^2 成分，認爲顆粒澱粉含量有關每一基因之顯隱等位基因平均分布於諸親間。測定平均顯性程度之 $(H_1/D)^{1/2}$ 比值介於 0 與 1 之間，W_r 依 V_r 之迴歸線切 W_r 於原點上方，因認定參試材料有關米粒顆粒澱粉含量之基因呈部份或不完全顯粒。提供親本顯隱因子數比之 K_d/K_r 值爲1.0832，近於 1，顯示參試 5 親本支配顆粒澱粉含量之顯隱性因子數目相等，而與親本間有關顆粒澱粉含量正與負等位基因頻度相等 $(H_2/4H_1)$ 之認定有異曲同工之處。

由 h^2/H_2 比檢出控制顆粒澱粉含量之部份顯性因子數爲 2 對，經藉親本均值 (Y_r) 與對應W_r+V_r 值之相關分析與 W_r 依 V_r 之迴歸分析結果，建議高顆粒澱粉含量者爲顯性，親本之顯性次序爲45321，親本表現之次序爲54312。

膠體硬度是 IRRI 在1973年左右發展出來進一步再細分高顆粒澱粉含量秈米食用品質之指標。數據顯示本試驗供試材料膠體硬度之遺傳成分中，累加性效應與顯性效應均極顯著，而 $D-H$ 爲負值，但不顯著，指出顯性效應對控制米粒膠體硬度變異之效應可能比累加性效應强，但支配力之差異有限。但無論如何，本性狀之狹義遺傳率較廣義遺傳率值低很多，暗示顯示效應對本性狀頗具效應。平均顯性程度估值近於 1，認定有關膠體硬度之基因爲完全顯性。綜合不顯著之 F 成分、b_2 變因及 $D-H_1$，認爲每一基因顯隱等位基因平均分布於諸親間。$H_2/4H_1=0.2412 \doteqdot 0.25$，建議親本間正與負等位基因頻度相等。親本顯隱因子總數比 $K_d/K_r=1.2262$，似有顯性因子數較隱性因子數爲多之傾向。而膠體硬度之顯性主效因子數則未能估出。經藉親本均值與對應 W_r+V_r 值之相關分析與 W_r 依 V_r 迴歸分析結果，建議短的膠體展流爲顯性，參試親本之顯性次序爲45132，表現次序爲12345。

穀粒之長寬厚 (grain dimensions) 是市場銷售若干重要性狀之部份。表 4 數據顯示糙米之粒長變異主要受累加性與顯性效應所支配，顯性效應遠小於累加性效應，而與糙米粒長有極高之狹義遺傳率值相對應（表 5），判定親本間顯隱等位基因相對頻度之 F 成分爲顯著之正值，指出顯性等位基因較隱性爲多，與提供估計親本總顯隱基因數比 (K_d/K_r) 亦指出顯性基因佔多數之結果相符。H_1、H_2 及 h^2 雖顯著，但 $(H_1/D)^{1/2}$ 值介於 0 與 1 之間，建議粒長性狀之有關基因爲部份或不完全之顯性。供試材料中估得 1 對具顯性效應之主效因子。親本平均與對應 W_r+V_r 之相應係數爲顯著之負相關，此建議長粒爲顯性，圖 1 及圖 2 可知參試親本之顯性次序爲 21543，但親本表現次序則爲25134。而親本間正與負等位基因頻度則似不等 $(H_2/4H_1=0.2158)$。

粒寬與粒厚之遺傳行爲與粒長很類似，一如粒長，累加性與顯性效應爲粒厚及粒寬遺傳變異之主要成分，且累加性效應對兩性狀之影響皆顯著地大於顯性效應。顯著之正 F 值及 K_d/K_r 值均大於 1，分別指出粒長與粒厚兩性狀之顯性等位基因遠多於隱性基因，及親本顯性基因總數較隱性者多。由迴歸圖解及變方分析估得之平均顯性程度建議兩性狀之各該有關基因呈部份或不完全顯性。估得呈部份顯性之主效基因分別爲粒寬 1 對，粒厚 2 對。諸親本正與負等位基因頻度亦不等。粒寬與粒厚兩性狀之親本平均與對應 W_r+V_r 呈不顯著之負相關，亦即由此 Y_r 與 W_r+V_r 之相關係數似無法判定粒之寬窄與粒之厚薄何者爲各該性狀之相對顯性，但無論如何，由 W_r 依 V_r 之迴歸分析(圖 1)可建議，粒寬之親本顯性次序爲43512，親本表現次序爲43152。粒寬者爲顯性；粒厚之親本顯性次序爲43152，親本之表現次序爲34215，粒厚者爲顯性。

米粒之顆粒澱粉含量與膠體硬度、蛋白質含量、鹼質擴散度及粒長成極顯著之負相關，與粒厚及粒寬兩性狀則成極顯著之正相關。其餘品質性狀間除蛋白質含量與粒寬之相關不顯著外均顯著，而各性狀之爲正相關或負相關，則詳如表 6 所列。

表 6、品質與穀粒性狀間之簡單相關係數

Table 6. Simple correlation coefficients among quality and grain characteristics.

Characteristics	Cooking and eatingquality				Grain dimensions of brown rice		
	Amylose content	Gel consistence	Protein content	Alkali spreading score	Kernel length	Kernel width	Kernel thickness
Amylose content	—	－0.86**	－0.55**	－0.87**	0.37**	－0.56**	0.52**
Gel consistence			0.48**	0.87**	－0.35**	0.47**	－0.51**
Protein content				0.54**	－0.13ns	0.29**	－0.22*
Alakli spreading score					－0.35**	0.63**	－0.54**
Kernel thickness						－0.83**	0.94**
Kernel lenhgt							－0.91**
Kernel width							—

*, ** : Statistically significantat 1% and 5% probability levels, respectively.

ns : Non-significant.

討　論

本省秈稻之栽培面積逐年急速下降，雖晚近各場所投下了不少努力，但栽培面積尚在不斷減少中，黃[9]之綜論指出，秈稻之重要性有落得與糯稻相近之慮。諸多研究[2,5,10]與綜論[3,4,8,9]指出長粒秈稻之容重量與稻米品質未臻理想是產銷上的致命傷，多數建議是修改有關收購法令，降低收購標準[2,5,10]等，此類建議實非建設性之解決問題之方法。由於半矮性秈稻之高產潛力似來自半矮性，而非長粒型[8]，又已知長粒不利容重量與若干碾米品質，而秈米之烹調與食用品質得由膠化溫度、蛋白質含量、顆粒澱粉含量及膠體硬度判定之，因而認爲短粒及低顆粒澱粉含量秈米之育成應爲內銷秈稻之育種方向。因此於1981年起接受農發會輔助，針對秈米烹調與食用品質性狀及穀粒大小作全面之遺傳研究，此觀點與堀末[12]對本省秈稻育種應以縮短粒長並降低顆粒澱粉含量之建議不謀而合。研究中品質性狀之簡單相關係數估計發現，白米之顆粒澱粉含量與糙米粒長成極顯著負相關，似乎低顆粒澱粉含量與短穀粒似不可兼得，但國際上概以長粒而其顆粒澱粉含量爲中至高（20—25%爲中，25%以上爲高）之秈米爲主[24,26,27,29]，及研究中粒長與顆粒澱粉含量之相關係數是由自交之親本與顆粒澱粉含量有雜種優勢現象之 F_1 組合（表 2）估得之事實，雖表 6 數據顯示白米之顆粒澱粉含量與粒長成極顯著之負相關，但並不因而認爲短粒且低顆粒澱粉含量秈稻品種之育成有困難。

膠化溫度是澱粉之一種物理特性，乃在熱水中的澱粉顆粒開始成不可逆之膨脹，並失去其極性（birefringence）及結晶構形（crystallinity）之臨界溫度。米粒之膠化溫度通常界於55至 79°C 之間，習慣上稱低於 70°C 者爲低膠化溫度（鹼質擴散測定 6 及 7 級者屬之），70-74°C 者爲中膠化溫度（鹼質擴散度 3 — 4 級者），74°C 以上爲高膠化溫度（鹼質擴散度 1 — 2 級者）。高膠化溫度之白米在通常標準煮飯法下常不能煮熟，烹煮過久（overcooked）則飯粒過軟而崩解[26,27]。飯食白米以中至低膠化溫度者爲宜，罐製食品等其他點心類以高膠化溫度者爲佳[3,24,27]。早期綜論認爲膠化溫度之遺傳雖不十分清楚，但一般相信其遺傳行爲相當簡單[23]，可能僅受 1 — 2 對主效基因所控制[7,16,17,22,23,33,34,43]，遺傳率頗高，高膠化溫度爲顯性[7,16,17,23]。晚近 Somrith *et al.* [42] 及 Singh and Singh[41] 分別以世代平均值法及全互交法檢出鹼質擴散度除了累加性效應外，尚有各類交感作用存在。陳[7]報告累加性與顯性效應俱顯著，且顯性作用大於累加性效應，Mckenzie and Rutger

[34]，及 Mckenzie[33] 則指出若干 F_2 組合無法歸納出其遺傳模式，有的組合則可能有 1 對主效因子，有的可能有具累加性效應之主效基因若干對，並發現有若干對之修飾因子存在。本研究數據則顯示累加性與顯性效應對控制鹼質擴散度很重要，累加性效應遠大於顯性效應，鹼質擴散度小者（高膠化溫度）爲部份顯性。此等結果印證已發表之報告可知，以鹼質擴散度爲質的性狀所作之研究概認爲本性狀之遺傳行爲較爲簡單[7,16,17,22,23,34,43]，而將本性狀視爲量的性狀之報告則遺傳行爲頗爲複雜[7,41,42]。唯異中有同的是所有報告均顯示米粒擴散度之遺傳率値均相當之高，故育種選拔效果之保持似無問題。

蛋白質含量雖與烹調品質有關，但亦常被視爲營養品質性狀。蛋白質含量之高低除與白米烹調所需時間與煮飯用水有關外，與煮成飯粒之色澤亦有關，通常高蛋白質含量之飯粒呈人們較不喜歡之黃褐色。米粒之蛋白質介於 5 —16% 之間[24,26,27]，有關蛋白質含量之遺傳行爲被認爲十分複雜[23]，最近之研究指出低蛋白質含量對高者爲顯性，有細胞質效應[15,16,17]。全互交之分析結果爲累加性與顯性效應均顯著，顯隱對立基因不平均分布，部份基因帶顯性，且其程度爲超顯性，遺傳率低[15]；此等結果大致與本研究相似，但本研究中因累加性效應遠大於顯性效應，而得較高之遺傳率是所當然。就營養品質及烹調與食用品質言，兩者對蛋白質含量高低之要求顯然不同；蛋白質含量愈高，營養品質愈佳，但因之帶給烹調與食用品質不利之影響亦越大，然截至目前之研究報告均不曾建議不影響烹調與食用品質之臨界蛋白質含量。因之就米粒營養及烹調與食用品質等三方面來考量最適之米粒蛋白質含量，應是米質研究者之一重要工作。

米粒顆粒澱粉含量被認爲是影響秈米食用品質之最主要因素，非糯白米之含量介於 8 —37% 之，習慣上分成低（20% 以下），中（20—25%）及高（25% 以上）等三級[24,26,27]。高顆粒澱粉含量之飯粒質地粗糙不具黏性，低顆粒澱粉含量之飯粒濕潤而黏，中顆粒澱粉含量之飯粒則介於兩者之間。各類型米隨各地區人民之食性而各佔有其市場，在本省則以低顆粒澱粉含量之黏性米較受歡迎。質的性狀研究指出高顆粒澱粉含量對低顆粒澱粉含量爲不完全顯性，含量之高低除受 1 至 2 對主效基因控制外，尙受若干修飾基因左右[6,13,16,17,18,19]。世代平均值法研究指出本性狀之遺傳變異除累加性與顯性外，各非對立因子之交感作用亦存在[16,17,42]，4×4 全互交分析證實累加性效應遠大於顯性效應，親本間正負等位基因不等，顯隱因子數目亦不等，低含量對高含量爲不完全顯性[41]，或高含量對低量爲不完全顯性[7]，綜合前人研究印證本研究之累加性與顯性效應皆顯著，且累加性效應遠大於顯性效應，正負等位基因頻度相等，顯隱基因數目亦等，高含量對低含量爲顯性，而顯性程度不完全等之結果，可知目前有關顆粒澱粉含量之遺傳研究雖較多，以質的性狀爲前提之結果較一致，量的研究之結論則較不一致；考其原因或是目前秈米顆粒澱粉含量之遺傳變異性（genetic diversity）很大[24,26,27]，而目前已發表報告所有供試親本數不大（包括本研究），所能涵蓋之遺傳背景不够廣泛，故所作推論之周延性不足故也。

四個烹調與食用品質性狀中，膠體硬度之測定是開發得較晚之品質檢定技術，以往質的性狀之研究指出米粉膠體展流度短之高硬度對低硬度爲顯性，有關因子數爲一對[6,18]，膠體硬度與顆粒澱粉含量成負相關[6]。而本研究中發現本性狀之累加性與顯性效應均顯著，基因之顯性程度完全，高硬度對低硬度爲顯性，遺傳率亦高。凡此似指出本性狀之早世代之單株選拔應屬有效。

穀粒大小之研究開始得很早，據 Chang and Li[16] 及 Chang and Somrith[17] 引述 Dave 對粒長顯性順序之觀察爲長粒＞中粒＞短粒＞極短粒，有累加性與顯性效應[16,17,40]，粒寬與粒厚均受數量基因之控制。本研究發現粒長，粒寬及粒厚之遺傳變異模式很相近（表 4 及表 5），累加性效應均遠大於顯性效應，且長粒對短粒爲顯性，寬粒對窄粒爲顯性，厚粒對痛粒爲顯性。綜合前人與本研究之結果，認爲穀粒大小之遺傳模式雖亦如其他 4 性狀般之複雜，但因爲本性狀具一目瞭然之特性，且累加性效應又遠大於顯性，遺傳率値亦高，故實爲最容易掌握之性狀。

Hayman[21] 全互交法有①親本爲二元體分離，②正反交無差異，③非對立因子間獨立作用（無

基因交感作用），④無複等位基因，⑤同型結合體親本，⑥基因獨立分布親本間（無連鎖）等六個遺傳假說。據李[1]之綜論指出，由遺傳學之觀點而言 Hayman[20,21] 全互交假說中之基因獨立分布親本間及非對立因子間獨立作用等兩個前提不易被接受，且親本數超過10個以上時估值才正確，同文指出基因之上位性（即基因間之交感作用或非對立因子間之作用未獨立）會影響一般組合力與特定組合力變力之估值，親本數較少時如行全互交分析，則須用統計上之固定型模式爲妥當。而本研究是以 F_1 集團爲材料，自無連鎖干擾。未估算一般及特定組合力，故研究中 a 及 b_3 變因（表3）雖顯著，自無非對立因子間作用獨立與否，是否影響組合力之正確估計等問題。本研究遺傳變異成分之估計是按 Hayman[21] 1954年之全互交組合之解析與理論進行，理論上應屬固定型模式，其各估值若有偏估，無疑偏差（inflated）極微。

綜合本研究之結果認爲以譜系法進行秈米育種時，建議在初期龐大集團首行合適粒長之篩選，並伴隨膠化溫度及膠體硬度之進一步淘汰後，於較後期世代再進行定量費時耗工顆粒澱粉含量之定量選拔，應是一可行之方法。當然在品質性狀之決選進行中，農藝性狀之篩選是相伴而行。

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Inheritance of Quality and Grain Characteristics in *Indica* Rice[1]

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Summary

The inheritance of 7 quality and grain characteristics related to cooking and eating qualities as well as grain dimensions in *indica* rice were studied by means of 5×5 diallel crosses including parents and reciprocal crosses.

The genetic variations of 7 quality characteristic evaluated were significant. Both additive and dominance effects were important for all-7 quality characteristics. Furthermore, additive effects were significantly larger than dominance effects for all quality characteristics evaluated except for gel consistence. Estimated heritabilities for all characteristics were very high, indicating that a major portion of phenotypic variability was controlled by additive effects. Maternal effects existed in alkali spreading score, amylose content, gel consistence, kernel width and kernel thickness.

Degrees of dominance for 7 quality characteristics estimated by graphic and variance analyses showed partial or incomplete dominance except that gel consistence was complete dominance. Directions of dominance, evaluated by regression plotting and the order of parental dominance, were toward low alkali spreading score, low proteint content, high amylose content, high gel consistence, long grain length, wide grain width and thick grain thickness.

The average frequency of positive and negetive alleles in parents were about equal for cooking and eating qualities, but not equal for grain dimensions. Number of dominant genes exceeded recessive genes for alkali spreading score, protein content and amylose content, however, recessive genes exceeded domianat genes for gel consistence and grain dimensions.

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水稻生長分析及吸光係數之研究[1]

蔡金川[2]

摘要：於民國72年第二期作栽植早、中、晚熟水稻品種豐錦、臺農67號及臺中秈3號作試驗，進行生長分析及羣落內吸光係數之測定，比較三品種之差異，由試驗結果可知早熟品種之下位葉及總葉面積指數（上位葉＋下位葉）於抽穗期呈現高峰，上位葉之葉面積指數在抽穗後之乳熟期才達到高峰。中熟品種臺農67號之總葉面積指數於孕穗期呈現高峰，上位葉之葉面積指數亦在孕穗期達到高峰，抽穗前後二週變動較少，保持平穩直線的趨勢，至糊熟期才下降，下位葉之葉面積指數於抽穗期達到高峰，然後急速下降，晚熟品種臺中秈3號之上、下位葉面積指數及總葉面積指數皆於孕穗期出現高峰。

豐錦之 CGR, NAR 及 RGR 自取樣初期（移植後43天）因生育期之後移而急速下降，臺農67號此三者於整個採樣時期（移植後43—85天）呈現近似波浪型的變動，亦皆於抽穗期出現次高峰，而臺中秈3號之 CGR 同樣出現波浪型的曲線，抽穗前後一週各出現高峰，但比他兩品種爲低，自採樣初期至抽穗期 NAR 變化很小，至乳熟期才達高峰，然後急速下降，其 RGR 自生育初期至孕穗期變化很小近似直線軌跡，至抽穗期才開始遞減。其 CGR, NAR 及 RGR 於整個採樣時期之變化幅度較小，變化曲線趨於拋物線型。

至於吸光係數（K）三品種皆由取樣初期（移植後36天）而遞增，豐錦至成熟期突然大幅度下降，臺農67號也稍有降低的趨勢，而臺中秈3號整個採樣時期吸光係數的曲線最低，顯示其羣落內受光態勢良好。

水稻經由光合作用進行物質生產，乾物質爲其產物，稻穀乃乾物質之一部分，田中[(7)]指出水稻最終產量可用收穫時的全乾物重和收穫指數的乘積表示。因此，對羣落的乾物質生產過程的探討，有助於瞭解稻穀產量的形成，甚至可應用於提高產量的方法。

探討作物的全生育期間乾物質生產過程以生長分析（growth analysis）爲簡便方法。早在1920年代英國生物學家就開始使用，以葉面積與乾物重就可進行分析[(8)]。其方法乃植物或作物之一定生育期間（如每隔一週，每隔二週或每隔三週等），進行取樣，測定葉面積（展開之葉片）與乾物重（儘可能把葉、莖、根、花、子實等各部份分開），其測定值可計算葉面積指數（leaf area index, LAI），葉面積比（leaf area ratio, LAR），相對生長速率（relative growth rate, RGR），淨同化速率（net assimilation rate, NAR），作物生長速率（Crop growth rate, CGR）等。

本試驗以生長分析的方法，利用水稻在移植後36～92天之生育期間，每隔一週取樣進行分析，探討現行栽培之早、中、晚熟品種（豐錦、臺農67號、臺中秈3號），在不同生育期之生長情形，可知水稻各生育階級之生長趨勢，葉面積的分佈是否最有效的利用自然日照，以利製造更多之光合或產物。

並測定三品種各生育期羣落內吸光係數之變化情形，藉此可瞭解水稻羣落內葉片互相遮蔭的狀況，以及羣落理受光態勢的情形。諸如以上種種之生理現象，可供從事育種及栽培改進之參考。

1.臺灣省農業試驗所　研究報告第1229號　。
2.本所農藝系技士。臺灣省 臺中縣 霧峰鄉。

材料與方法

本試驗於民國72年第二期作，在本所試驗田進行，供試早、中、晚品種分別爲豐錦、臺農67號及臺中秈3號。採用逢機完全區集設計，行株距 25×25 cm，每小區 9.38 m^2 重複三次。肥料用量：硫酸錏、過磷酸鈣及氯化鉀分別爲 580、250、85 kg/ha，其他田間管理按一般管理法。

移植後 36 天開始採樣，每隔一週取樣一次。每次自田間採三小區十八叢之稻株，洗淨後立即採葉片，自上第1葉至第3葉爲上位葉，第3葉之下爲下位葉，以自動測定儀測葉面積，剪去根部後把樣品放在 100°C 下通風乾燥箱 1－2 小時後，再以 80°C 處理至完全乾燥，秤量全乾物重，用全乾物重與葉面積以下列公式求 CGR, NAR 與 RGR (13)。

$$CGR=\frac{W_2-W_1}{t_2-t_1} \cdots\cdots ①$$

$$NAR=\frac{(W_2-W_1)(l_nA_2-l_nA_1)}{(t_2-t_1)(A_2-A_1)} \cdots\cdots ②$$

$$RGR=\frac{l_nW_2-l_nW_1}{t_2-t_1} \cdots\cdots ③$$

$$CGR=NAR\times LAI \cdots\cdots ④$$

前後採樣時期分別爲 t_1 與 t_2 其各別時期所得之全乾物重爲 W_1, W_2 葉面積爲 A_1, A_2。生育後期採用④式求取 NAR，因該時期的生長已失去指數級數的關係。

配合採樣時期亦每隔一週上午 10 點左右測定羣落上面之入射光強度 I_0。及羣落內株間中央地面上5公分之光強度 (I) ，然後求其吸光係數[12]：K(light extinction colfficient$=-\frac{l_nI/I_0}{LAI}$) 。

結果與討論

由圖1知早熟品種豐錦之下位葉與總葉面積指數（上位葉＋下位葉）於抽穗期達到高峰，中熟品種臺農67號之上位葉葉面積指數與總葉面積指數以及晚熟品種臺中秈3號均於孕穗期出現高峰，這與前報告[3]相類似，而豐錦之上位葉葉面積指數延至抽穗後5天左右才達到高峰，臺農 67 號之下位葉葉面積指數於抽穗期才出現高峰。村田[5]認爲水稻在生育期間葉面積指數出現高峰期之變異性與品種特性或栽培管理有關。但此試驗結果所示上、下位葉葉面積指數在各生育期之變化情形以及高峰期之異同可能與葉片的發育與老化之生理現象有關。三品種葉面積指數於抽穗後之穀粒充實期皆顯著的下降，亦與葉片黃化或老化有關。

作物生長速率（CGR）由淨同化率（NAR）與葉面積指數（LAI）之兩要素所構成，若要提高 CGR，增加 LAI 較容易效果亦較好，特別是抽穗後之穀粒充實期皆有降低的趨勢，又前試驗如表1[4]，第一、二期作臺北與臺中地區抽穗期及乳熟期作物生長速度與產量皆呈顯著性的正相關，糊熟期大部份亦是正相關，其他與產量構成要素也大部份有正相關的關係。津野[6]也認爲 CGR 之大小，決定作物產量之豐收與否。前報告[3]認爲水稻抽穗期至糊熟期 LAI 與產量呈顯著性之正相關，又 IRRI[11]的報告也認爲水稻自開花至成熟期若有充分的葉面積指數可增加其乾物重。武田等[9,10]指出穗肥可以補充水稻穀粒充實期葉片氮素轉移至穗部形成葉片氮素的不足，即提高水稻穀粒充實期葉片氮素的含量，又認爲水稻穀粒充實期間葉片氮素含量較高者可增加 LAI 與提高光合成速度。而 Ray and Chondhuri[15]認爲 Cytokinin 或 kinetin 可延遲水稻老化。因此於穀粒充實期不影響羣落裡受光態勢之下，適當施穗肥或使用植物 Hormone 可提高葉面積指數，減少 CGR 大幅度的降低，乃提高產量有效方法之一。

表1. 水稻抽穗至糊熟期間生長速率與產量及產量構成要素之相關

Table 1 Correlations of crop growth rate (CGR) and yield Components at three growth stages.

Growth Period	Type	Crop Season	Yield Components								Grain yield g/hiil	
			Pamcle munber Per hill		Number of spikelets per panucle		Percentage of ripened Grains		1000-grain-Weight(g)			
			Taipei	Taichung	Taipei	Taichung	Taipei	Taichung	Taipei	Taichung	Taipei	Taichung
Heading	Japonica	1st crop (1981)	0.3430	0.5653*	0.1170	0.2421	0.5702*	0.0739	0.4057	0.4189	0.8770 **	0.6496 **
		2nd crop (1980)	0.5314*	0.6779**	0.5709*	−0.0968	0.6313**	0.4711	0.8744**	0.0704	0.8732 **	0.7352 **
	Indica	1st crop (1981)	0.1915	0.3430	0.4089	0.5278*	−0.1483	0.2564	0.8411**	0.0907	0.8419 **	0.6232 *
		2nd crop (1980)	0.4710	0.5210*	0.3052	0.1451	0.0822	−0.0888	0.7684**	0.5050	0.7690 **	0.6333 *
Milk-ripe Stage	Japonica	1st crop (1981)	0.5681*	0.2974	0.2602	0.5437*	0.5894*	0.0048	0.4972	0.3095	0.9428**	0.7479**
		2nd crop (1980)	0.3956	0.3305	0.4771	−0.1660	0.6609**	0.3708	0.8804**	0.5626*	0.8829**	0.6587**
	Indica	1st crop (1981)	0.2103	0.6308*	0.2243	0.1084	0.0166	−0.0891	0.6901**	0.1637	0.6906**	0.6219*
		2nd crop (1980)	0.2209	0.2711	0.4418	−0.3458	0.1199	0.5812*	0.9226**	0.7839**	0.9262**	0.5669*
Dough-ripe stage	Japonica	1st crop (1981)	0.2118	0.1059	−0.4387	0.2345	0.0286	−0.0514	0.2505	0.3073	−0.0222	0.4530
		2nd crop (1980)	−0.3402	−0.2377	0.5530*	0.3947	0.3260	−0.1233	0.6673**	0.1280	0.6705**	0.1481
	Indica	1st crop (1981)	−0.1471	0.0693	0.2461	0.5075	0.5501*	−0.4508	0.1705	−0.3838	0.1700	0.4745
		2nd crop (1980)	0.4201	−0.1825	0.2818	0.334	−0.1937	−0.0191	0.5579*	0.2765	0.5581*	0.3895

Note: *, ** Significant at 5% and 1% level , respectively.

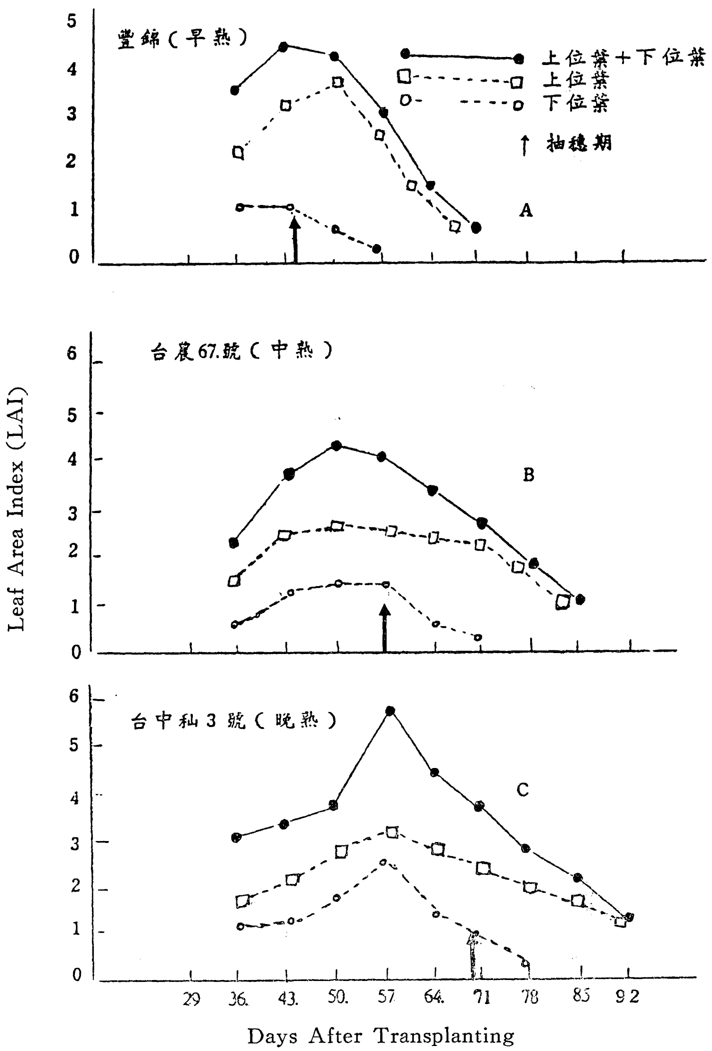
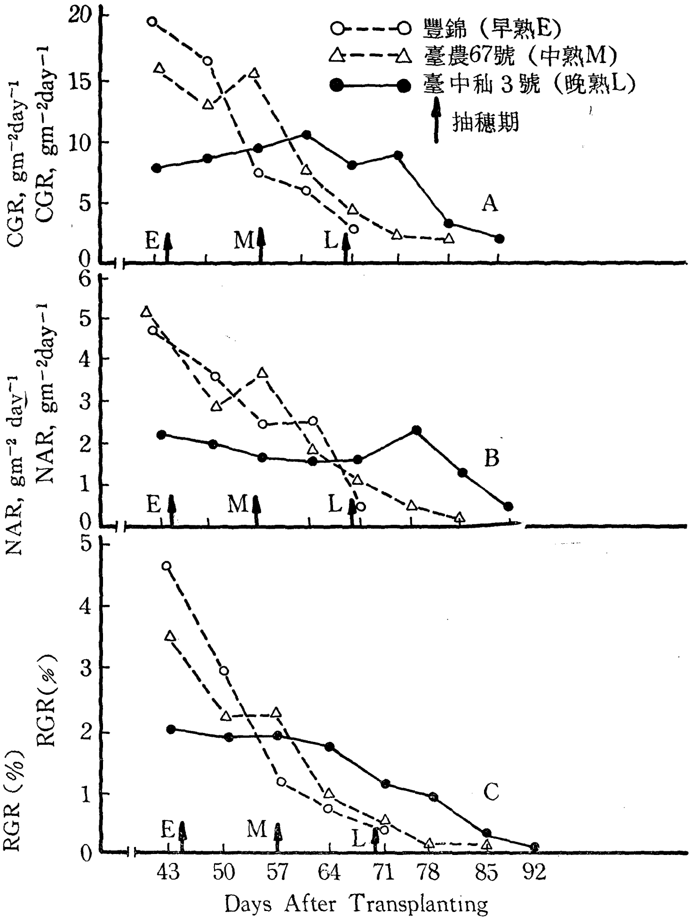


圖1. 二期作水稻各生育時期葉面積指數之變化。

Fig 1. Changes of leaf area index (LAI) of rice varieties at stages of development.

臺農 67 號之上下位葉面積指數與總葉面積指數於生育各期變化幅度較其他兩品種小，其上位葉之葉面積指數於抽穗前後兩週保持 2.5 左右，糊熟期才開始遞減，抽穗後總葉面積指數也緩慢下降（圖1 B）。如此可維持其較高的作物生長速率，這或許構成臺農 67 號高產的原因之一。津野[5]認爲構成水稻穀粒充實率降低的原因，乃是穀粒充實期間作物生長速率較低所致，若能維持較高的葉面積指數，可減少 CGR 的降低，也可提高穀粒充實率。

圖 2A 可知三品種 CGR 之變化趨勢，豐錦之 CGR 於抽穗前 2 天左右出現高峯，然後急速下降，田中[7]把水稻生育期間 CGR 之變化分爲 a. b. c 型，豐錦可屬於 b 型：生育初期 CGR 高，生育後期降低之品種，因此產量減低。臺中秈 3 號在孕穗期達到最高峯，抽穗後一週出現次高峯，這時 CGR 爲 8.9 $g/m^2/day$ 與日本高產品種之 CGR 9.1 $g/m^2/day$[5] 相差無幾，整個生育期間 CGR 之變化幅度較小，屬於 c 型：CGR 生育初期較低，生育後期仍維持較高 CGR 之品種，產量比較高。Oka[13] 等[13]稱之爲 "late-vigor type"。而臺農 67 號之 CGR 出現兩次高峯，孕穗期與



Days After Transplanting

圖 2. 二期作水稻各生育時期作物生長速率 (CGR) ，純同化率 (NAR,) 及相對生長速率 (RGR) 之變化。

Fig. 2 Changes of Crop Growth Rate (CGR), Net Assimillation Rate (NAR) and Relative Growth Rate (RGR) at stages of development.

抽穗期各一次，生育後期之 CGR 介於其他兩品種之間。因此可屬於 b. c 型之中間型的品種。

圖 2B 所示三品種之 NAR 於各生育時期之變化趨勢並不一致。早、中、晚熟三品種出現最高之 NAR 時期分別於抽穗期、幼穗形成期以及乳熟期。抽穗前 NAR 較高，穀粒充實期急速下降，一般抽穗前水稻葉片氮素含量較高[1,2]，這時 NAR 上昇可能與此有關。津野[6] 指出水稻生育初期至穀粒充實期葉片氮素濃度與光合成能力成比例的關係，而抽穗後若要提高 NAR，要有良好的株型如葉片直立型等受光態勢較好及葉片不易老化保持適當 LAI，並提高氮素含量。實際上提高 NAR困難較多，因 NAR 牽涉因子較複雜如光合成能力，受光能率，呼吸與葉面積之比皆是。改良品種增強其穀粒充實期之光合成能力及葉片直立型受光態勢良好，這些都有可能提高 NAR，同時增大CGR。

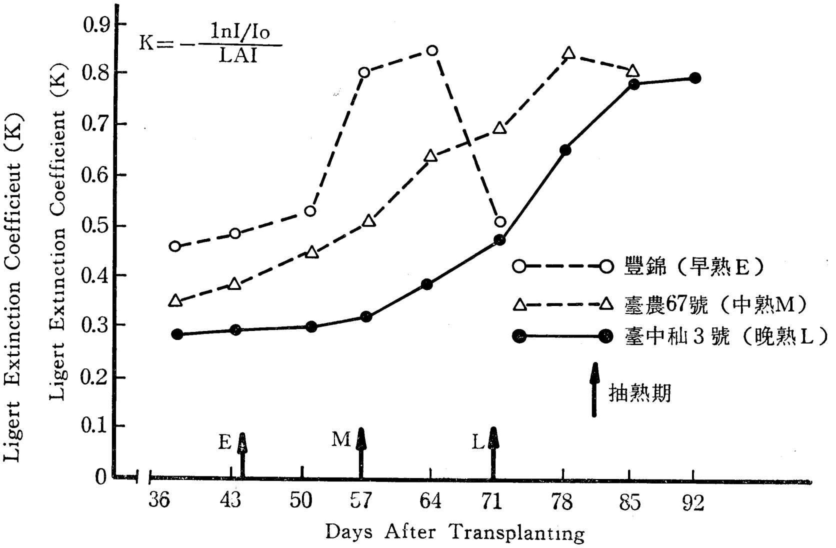
三品種之 RGR 大致由取樣開始因生育期之後移而遞減，豐錦與臺農 67 號呈急速的下降，而臺中秈3號生育各期 RGR 之曲線變化幅度較小，下降也最緩慢，穀粒充實期仍保持較高的 RGR (圖 2c) 。

表2. 水稻抽穗至糊熟期間吸光係數與葉長及葉角之相關。

Table 2 Correlations of light extinction coefficient (K) and leaf length and leaf angle at three growth stages.

Crop Season	Type	Leaf position	Heading leaf length Taipei	Heading leaf length Tai-chung	Heading leaf angle Taipei	Heading leaf angle Tai-chung	Milk-ripe stage leaf length Taipei	Milk-ripe stage leaf length Tai-chung	Milk-ripe stage leaf angle Taipei	Milk-ripe stage leaf angle Tai-chung	Dough-ripe stage leaf length Taipei	Dough-ripe stage leaf length Tai-chung	Dough-ripe stage leaf angle Taipei	Dough-ripe stage leaf angle Tai-chung
1st crop (1981)	Japon-ica	flag leaf	0.6676**	0.3549	0.5848*	0.5343*	0.4170	0.7405**	0.8970**	0.7598**	0.2403	0.7898**	0.7755**	0.7778**
		2nd leaf	0.6076*	0.4027	0.7022**	0.7673**	0.7103**	0.6809**	0.8852**	0.6862**	0.5646*	0.7110**	0.7511**	0.8271**
		3nd leaf	0.5934*	0.6978**	—	—	0.2492	0.6553**	—	—	0.1788	0.5631*	—	—
	Indica	flag leaf	0.2847	0.3929	0.4190	0.8662**	0.5662*	0.7259**	0.9754**	0.7993**	0.7635**	0.7995**	0.9370**	0.7638**
		2nd leaf	0.1893	0.3393	0.2888	0.5299*	0.4922	0.6418**	0.9530**	0.5113	0.6519**	0.7798**	0.9286**	0.8724**
		3nd leaf	0.1392	0.3969	—	—	− 0.1652	0.5275*	—	—	− 0.0905	0.7007**	—	—
2nd crop (1980)	Japon-ica	flag leaf	0.5155*	0.6234*	0.6374*	0.8193**	0.5889*	0.8695**	0.3681	0.7227**	0.3026	0.4670	0.1881**	0.4626
		2nd leaf	0.5082	0.4715	0.6499**	0.6549**	0.5589*	0.7373**	0.3714	0.6909**	0.3954	0.4478	0.2559	0.4415
		3nd leaf	0.2200	0.5998*	—	—	− 0.1082	0.5332*	—	—	− 0.2433	0.2698	—	—
	Indica	flag leaf	0.3386	0.5489*	0.4203	0.7649**	0.0874	0.7398**	0.5248*	0.5517*	− 0.0364	0.4612	0.3279	0.2484
		2nd leaf	0.2791	0.2764	0.3896	0.8030**	0.1599	0.3853	0.4647	0.0952	0.1381	0.2265	0.2299	0.1163
		3nd leaf	0.3319	0.1191	—	—	− 0.2769	0.3854	—	—	− 0.1933	0.2233	—	—

Note: *, ** Significant at 5% and 1% level, respectively. Angle was measured down-ward from the vertical line.



Days After Transplanting

圖3. 二期作水稻各生育期吸光係數（K）之變化

Fig. 3 Changes of light extinction coefficient (K) of rice varieties at stages of development.

圖3可知三品種之吸光係數均由調查初期即移植後36天開始，因生育期之後移而遞增，此與抽穗前 LAI 及抽穗後葉片垂直角度增加有關，葉片互相遮蔭影響羣落內的光度。豐錦於乳熟期吸光係數突然上昇至黃熟期又大幅度的下降。這可能與葉片黃化使葉面積減少以及葉片形態的改變有關。其他兩品種各生育期吸光係數之變化趨勢頗相似，而臺中秈3號於各生育期之吸光係數最小，乃受光態勢良好的表現。前試驗如表2 [4] 第一、二期作臺北與臺中地區抽穗至糊熟期水稻之吸光係數與葉長及葉片垂直角度成正相關，即葉片較短，直立型羣落裡的吸光係數（K） 會降低。因此改良株型乃是改進羣落內的受光態勢與降低吸光係數的有效方法。

綜合以上三品種於生育各期之 CGR、NAR、RGR 以及吸光係數等生理現象之反應情形而言，臺中秈3號於各生育期之變化幅度最小，尤其是穀粒充實期皆能保持較高的 CGR、NAR、 RGR 以及較小的吸光係數，維持良好的受光態勢，這對其光合成能力有莫大的幫助，若有良好栽培環境臺中秈3號則具有高產的潛力。

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Studies on the Growth Analysis and Light Extinction Coefficient in Rice Plants[1] .

Jin-Chuan Tsai[2]

Summary

Early, medium and late maturing varieties wexe grown under natural conditions at the experiment al field of Taiwan Agricultural Research Institute. A study was conducted to determine the pattern of growth and light interception in a field rice community.

The results showed that the lower and total LAI (upper+lower leaves) of early maturing variety attained highest LAI values at heading and decreased thereafter, upper leaves reached maxi mum LAI value at milk stage. The upper leaves of the medium maturing variety Tainung 67 had maintained the constant LAI for four weeks. At the dough-ripe stage it's LAI began to decline. The upper, lower and total LAI of late maturing variety Taichung sen 3 showed the maximum LAI value at booting stage.

From early sampling (43 days after transplanting), the CGR, NAR and RGR of Toyonishiki declined rapidly during the stages of development. The three curves (CGR, NAR, RGR) of Tainung 67 were shown in the similar pattern and the highest in heading. The sxmooth curve of CGR appeared in Taichung sen 3. It was shown two higher CGR, one week before and after heading, but lower than others. The RGR of Taichung sen 3. tended to straight line, decreased slowly aftər heading.

The light extinction coefficient of three varieties increased slowly from the early sampling(36 days after transplanting). But in the maturity, Toyonishiki declined suddenly and Tainung 67 decreased smaller. Light extinction coefficient was the smallest in Taichungsen 3 during the growth period. It would appear thal this variety has more light intensity among the varietal community.

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玉米臺農351號穗頂不充實原因之探討[1]

王強生　曹紹徽　劉大江[2]

摘要：玉米臺農 351號穗頂不充實之類型可分爲四種，即穗軸頂端萎縮、穎花未受精、子粒充實不良及混合型；本試驗於吐絲期進行降低族羣密度、套袋與人爲授粉等處理，探討花粉供應、供源能力、積儲容積與穗內子粒間競爭養份等因素對穗頂不充實問題的影響。試驗結果發現臺農351號玉米穗頂不充實長度爲3.39cm，占全穗長之20.1%，其中不稔部分即達2.51cm，唯子粒產量仍高達8.7t/ha；降低族羣密度二分之一（每公頃 29,400株）、套袋３～５日以延遲下位子粒發育與套袋６～10日以抑制部分下位子粒授粉充實，皆可顯著減輕穗頂不充實程度，增加充實穗長或上位子粒百粒重，但對一穗粒數與產量之提高則未具顯著效果。試驗結果顯示由於上、下位穎花與子粒在分化與發育方面的時序差異，使下位子粒具有較高的積儲強度（sink strength），對上位子粒之充實產生競爭與抑制作用。各處理植株營養器官乾物重在子粒充實期間持續上升，成熟時穗軸內非構造性碳水化合物濃度仍高，且自吐絲期開始降低族羣密度並不能有效提高產量，證明臺農 351號玉米之供源能力充足，積儲容積方爲產量限制因子，後者又與乾物質分配與轉流效率有關。本試驗未能證明人爲輔助授粉具有減輕穗頂不充實的效果，但鑑於穗頂不稔現象，抽穗與吐絲期之時間差距，以及較長的吐絲期間，仍不能否定花粉供應可能造成的影響。試驗結論認爲穗頂不充實現象爲多項因子共同作用的結果，且爲一品種特性，但與產量間的關係或對產量的影響並不明確，由於臺農351 號爲具有高產潛力的品種，在未育成穗頂完全充實的新品種以前，仍可由適當的栽培方法達到高產的目的。

臺農 351號爲臺灣省農業試驗所育成之單雜交玉米品種，植株强健，抗多種病害，對氮肥有極佳的反應，故產量高，平均每公頃在6t以上，爲目前稻田轉作計畫中所推薦的主要玉米品種。唯臺農 351號品種果穗頂端之子粒可能有不充實現象，依據民國72年秋作全省玉米栽培試驗結果（未發表），不充實穗長介於1—4.6cm之間，占全穗長之６～28.8%，平均爲 16.1%；Wang *et al.*[23] 在不同氮肥施用量試驗中亦發現，臺農351號玉米穗頂不充實長度平均爲 2.2cm，占總穗長之14.4%，並估計如能克服此一缺點，產量有提高８～12%之可能。由此可知臺農 351號品種穗頂不充實現象普遍，有必要深入探究其原因，進而謀求改進之方。

玉米穗頂不充實問題並非罕見，依據 Daynard and Duncan[5]、Egharevba *et al.*[8] 及 Hanway[12] 等之報告計算，許多國外品種之不充實穗長占全穗長之2.4～17%，但平均僅爲６%左右，較臺農 351號爲低。許多原因皆可能導致玉米穗頂不充實，諸如遺傳（品種）特性[5,12]、穗內分化與發育之時序差異[3,16]、開花與吐絲時間差距過長[4,15]、穗內不同部位子粒間競爭養份[19,21,22]及光合成產物之供需平衡問題[15,17,25]等。本試驗針對上述可能原因，藉變更族羣密度、抑制下位子粒發

1.臺灣省農業試驗所　研究報告第1230號。本試驗承行政院農業委員會補助部分經費，王碧玉與王祝仙小姐協助部分調查工作，謹致謝意。

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育、延遲授粉及人爲輔助授粉等處理，探討影響臺農 351號玉米穗頂子粒發育不良的原因。

材料與方法

採用臺農351號（Tainung 351）玉米品種爲材料，於民國73年秋作在臺中縣霧峰鄉臺灣省農業試驗所農場進行試驗。73年9月15日播種，行株距爲 85×20cm，每穴2粒種子，出土後間拔爲1株，相當於每公頃栽植58,800株。小區面積爲 40m²，重複4次，採用完全逢機區集設計。肥料用量爲 N：P_2O_5：K_2O＝200：100：90kg/ha，分別以硫酸銨、過磷酸鈣及氯化鉀之型態施用，方法已於前文[23]報告；又施用萌前殺草劑Primextra（Ciba-Geigy公司產品），用量爲3.5 l (a.i.)/ha，並適時防治病蟲害，植株抽穗前行中耕培土一次。

本項試驗於玉米吐絲期進行以下各項處理：

1. TMP：間拔行內植株至一半密度（每公頃29,400株），並輔以人爲授粉。
2. TNP：間拔玉米行內植株至一半密度。
3. CKMP：人爲輔助授粉。
4. CKNP：對照。
5. BMP：於玉米植株開始吐絲時套袋6～10日，並輔以人爲授粉。
6. BNP：於玉米植株開始吐絲時套袋6～10日。
7. DMP：於玉米植株開始吐絲時套袋3～5日，並輔以人爲授粉。
8. DNP：於玉米植株開始吐絲時套袋3～5日。

人爲授粉係於玉米雄穗開花後一週起爲之，每天自花粉供應區收集花粉進行人爲授粉，連續 9天。依據73年春作預備試驗結果，套袋5日以內不致影響花絲壽命，可收延遲授粉之效果，套袋6～10日則抑制部分中、下位穎花受精，可改變玉米果穗之積儲容積（sink capacity）。

植株生育期間調查雄穗抽出（tasseling）與開花（anthesis）期及雌穗吐絲（silking）期。除間拔（TMP與TNP）處理外，其餘處理均以單株爲單位記錄各生育期、套袋及授粉時間，以提高試驗之準確程度。

於吐絲及成熟期分別自每小區採取6～8株樣品，將植株區分爲葉片、莖稈（含葉鞘）、雄穗、苞葉、穗軸及種子等部位，測定其乾物重。成熟期另於每小區選取15穗，於 80°C 烘乾48小時後調查以下各性狀：不稔實長度（穗頂穎花未受精部分之長度）、不充實穗長（穗頂不稔實及子粒不充實部分之長度）及充實穗長（全穗長與不充實穗長之差）；又將全穗依穗長等分爲上、中、下三部位，分別測定各部位之穗周、軸周、粒數、粒重及計算百粒重。

所有樣品於秤量乾物重後均經Wiley mill以40目（mesh）篩磨粉，再於80°C烘乾24小時後分析全氮（N）與非構造性碳水化合物（total nonstructural carbohydrates，簡稱TNC）濃度，前者係依semi-micro Kjeldahl 法，後者係依Smith[20]法分析，每一樣品均分析2次。試驗結果均進行變方分析，且以鄧肯氏多變域分析（Duncan's New Multiple Range Test）測驗其顯著性，部分資料並以最小自乘法（L. S. D.）測定其差異顯著程度（資料未列出）及進行相關分析。

結　　果

試驗於9月15日播種，9月20日出土，雄穗於出土後46日抽出，2日後開花（植株間差距爲0～5日），開花後4日吐絲（變域爲1～8日）。吐絲期植株各部位乾物重經變方分析結果，小區間之差異不顯著，顯示植株生長頗爲一致，各部位平均每株乾重爲葉片 27.87g、莖稈51.64g、雄穗5.81g、苞葉7.62g及穗軸2.22g，全株總重爲95.16g，各項結果與72年秋作試驗結果（未發表）相近。

臺農 351號玉米於吐絲期進行各項處理，成熟時植株各部位之乾物重列於表1。以對照(CKNP)而言，葉片乾重爲每株33.48g，莖稈爲 63.82g，亦即營養器官之乾物重較吐絲期增加17.79g；苞葉

乾重爲18.31g，穗軸爲28.18g，二者合計較吐絲期增加36.65g；雄穗乾重爲 4.29g，子粒爲147.79g；全株乾物重於吐絲後增加200.7g。子粒產量爲每公頃8.69t。

就各處理間之乾物重資料（表1）進行比較，間拔使族羣密度減半兩處理（TMP與TNP）植株各部位（葉片除外）乾重均有增加的趨勢，但僅自然授粉處理（TNP）區莖稈、苞葉及全株總乾物重之增加達顯著水準；於吐絲期降低族羣密度並無法使單株子粒產量顯著提高。套袋6～10日以抑制中、下位子粒發育兩處理（BMP 與 BNP）之全株總重與對照相同，但子粒產量顯著降低，BMP與BNP分別爲對照之84.7%與81.8%，其他各部位之乾重則多顯著增高，尤以莖稈與苞葉之增加最爲明顯。套袋3－5日以延遲授粉兩處理（DMP與DNP）未顯示處理效果，植株各部位之乾物重皆與對照相近。

Table 1. Dry weight (g/plant) and relative percentage to control (CKNP treatment) of plant components of Tainung 351 maize at maturity as affected by various treatments

Treatment[1]	Leaf	Stalk	Husk	Cob	Grain	Tassel	Total
TMP	31.50c[2] (94.1%)	69.84ab (109.4%)	21.78abc (119.0%)	32.63a (115.8%)	161.76a (109.5%)	4.50ab (104.9%)	322.02ab (108.8%)
TNP	32.88bc (98.2%)	77.86a (122.0%)	23.52ab (128.5%)	31.84ab (113.0%)	162.78a (110.1%)	4.52ab (105.4%)	333.39a (112.7%)
CKMP	34.23abc (102.2%)	69.26ab (108.5%)	18.90bc (103.2%)	28.35b (100.6%)	146.58b (99.2%)	4.95ab (115.4%)	302.14b (102.1%)
CKNP	33.48bc (100.0%)	63.82b (100.0%)	18.31c (100.0%)	28.18b (100.0%)	147.79a (100.0%)	4.29b (100.0%)	295.86b (100.0%)
BMP	36.09ab (107.8%)	76.45a (119.8%)	24.60a (134.4%)	30.67ab (108.8%)	125.13b (84.7%)	5.19a (120.9%)	298.12b (100.8%)
BNP	37.88a (113.1%)	75.18a (117.8%)	25.45a (139.0%)	33.66a (119.4%)	120.56b (81.8%)	4.50ab (104.9%)	297.22b (100.5%)
DMP	34.14abc (102.0%)	72.20ab (113.1%)	21.69abc (118.5%)	30.63ab (108.7%)	156.84a (106.1%)	4.23b (98.6%)	319.73ab (108.1%)
DNP	32.09bc (95.8%)	71.26ab (111.7%)	20.52abc (112.1%)	29.87ab (106.0%)	157.05a (106.3%)	4.79ab (111.7%)	315.57ab (106.7%)

[1] TMP : thinned to half density and supplemented with manual pollination. TNP : thinned to half density. CKMP : supplemented with manual pollination. CKNP : control. BMP : ears bagged for 6-10 days and followed by manual pollination. BNP : ears bagged for 6-10 days. DMP : ears bagged for 3-5 days and followed by manual pollination. DNP : ears bagged for 3-5 days.

[2] Means with the same letter are not significantly different at 5% probability level by Duncan's New Multiple Range Test.

本試驗中之8個處理可分與4組，每組內均包含人爲輔助授粉（以M代表）及自然授粉（以N代表）二項處理，但就植株各部位之乾物而言，組內比較均未顯示顯著性差異，亦即吐絲期是否於自然授粉之外再輔以人爲授粉，對成熟期之產量與乾物重並無明顯的影響。

與穗長有關性狀之表現列於表2，對照（CKNP）處理之全穗長爲16.88cm，不充實穗長爲3.39cm，其中不稔實部份爲2.51 cm，分別佔全穗長之20.1%與14.9%。表2資料同時顯示，就不充實部份之絕對長度而言，多數處理均可獲致減低的效果，例如族羣密度減半且輔以人爲授粉（TMP）之穗頂不充實長度爲2.73cm（佔全穗長之15.3%），套袋6—10日（BMP與BNP）處理爲2.13—2.38 cm（11.1—12.4%），套袋3－5日（DMP與DNP）處理爲2.29—2.60cm（12.8—14.8%）。不

稔實部份長度則僅在BMP與DMP處理獲得顯著之降低效果，分別爲1.96cm與1.87cm，佔全穗長之11.1%與12.8%。各處理對總穗長之作用則僅見於套袋6—10日處理（BMP與BNP），較對照之增加幅度約爲14%。充實穗長受總穗長與不充實穗長之影響，族羣密度減半且輔以人爲授粉（TMP）

Table 2. Characters related to ear length of Tainung 351 maize as affected by various treatments

Treatment[1]	Length of Ear (cm)				A/D	B/D	C/D
	Unfilled (A)	Nonfertilized (B)	Filled (C)	Total (D)			
TMP	2.73bc (80.5%)	2.44a (97.2%)	15.17c (112.5%)	17.90ab (106.0%)	15.3%	13.6%	84.7%
TNP	3.11ab (91.7%)	2.58a (102.8%)	14.55cd (107.9%)	17.66b (104.6%)	17.6%	14.6%	82.4%
CKMP	3.00ab (88.5%)	2.21ab (88.0%)	13.46d (99.8%)	16.46b (97.5%)	18.2%	13.4%	81.8%
CKNP	3.39a (100.0%)	2.51a (100.0%)	13.49d (100.0%)	16.88b (100.0%)	20.1%	14.9%	79.9%
BMP	2.13d (62.8%)	1.96b (78.1%)	17.10a (126.8%)	19.23a (113.9%)	11.1%	10.2%	88.9%
BNP	2.38cd (70.2%)	2.30ab (91.6%)	16.80ab (124.5%)	19.18a (113.6%)	12.4%	12.0%	87.6%
DMP	2.29cd (67.7%)	1.87b (74.5%)	15.56bc (115.3%)	17.86ab (105.8%)	12.8%	10.5%	87.1%
DNP	2.60bcd (76.7%)	2.30ab (91.6%)	14.99c (111.1%)	17.58b (104.1%)	14.8%	13.1%	85.3%

[1] See Table 1 for description of treatment abbreviations.

Table 3. Peripheral length (cm) of ear and cob of Tainung 351 maize as influenced by various treatments

Treatment[1]	Ear Periphery			Cob Periphery		
	Tip	Middle	Basal	Tip	Middle	Basal
TMP	11.63ab (112.7%)	14.64ab (98.5%)	15.84ab (100.2%)	7.61bcd (103.3%)	9.23a (101.8%)	10.16a (100.7%)
TNP	10.28c (99.6%)	14.89a (100.1%)	15.98a (101.1%)	7.12a (96.6%)	9.08a (100.1%)	10.12a (100.3%)
CKMP	10.69bc (103.6%)	14.92a (100.3%)	15.62ab (98.8%)	7.40cd (100.4%)	9.07a (100.0%)	10.00a (99.1%)
CKNP	10.32c (100.0%)	14.87a (100.0%)	15.81ab (100.0%)	7.37cd (100.0%)	9.07a (100.0%)	10.09a (100.0%)
BMP	11.46abc (111.0%)	14.02bc (94.3%)	13.86c (87.7%)	7.99ab (108.4%)	9.05a (99.8%)	9.43c (93.5%)
BNP	12.09 a (117.2%)	13.93c (93.7%)	13.60c (86.0%)	8.19a (111.1%)	9.15a (100.9%)	9.57bc (94.8%)
DMP	11.45abc (110.9%)	14.75a (99.2%)	15.38b (97.3%)	7.89abc (107.1%)	9.18a (101.2%)	9.85ab (97.6%)
DNP	11.62ab (112.6%)	14.65ab (98.5%)	15.49ab (98.0%)	7.75abc (105.2%)	9.03a (99.6%)	9.77abc (96.8%)

[1] See Table 1 for description of treatment abbreviations.

Table 4. Kernel number (no./plant), kernel weight (g/plant) and 100-kernel-weight (g) of Tainung 351 maize as affected by various treatments

Treatment[1]	Kernel Number				Kernel Weight				100-kernel-weight			
	Tip	Middle	Basal	Total	Tip	Middle	Basal	Total	Tip	Middle	Basal	Total
TMP	139 a	259 a	225 a	623 a	26.43ab	66.49ab	64.12a	161.76a	19.04bc	25.65b	28.48b	25.98b
	(109.0%)	(109.7%)	(110.5%)	(109.8%)	(117.5%)	(100.8%)	(103.9%)	(109.5%)	(108.2%)	(92.1%)	(93.6%)	(99.7%)
TNP	103 c	241 ab	209 a	553 a	20.23bc	69.64a	67.46a	162.78a	19.57bc	28.92a	32.35a	29.39a
	(81.0%)	(102.1%)	(102.7%)	(97.6%)	(90.0%)	(105.5%)	(114.6%)	(110.1%)	(111.3%)	(103.8%)	(112.0%)	(112.8%)
CKMP	112 bc	221 bc	203 a	536 a	18.09c	62.77ab	59.59a	146.58a	16.02d	28.50ab	29.58ab	27.33b
	(88.2%)	(93.7%)	(99.5%)	(94.5%)	(80.4%)	(95.1%)	(101.2%)	(99.2%)	(91.1%)	(102.3%)	(102.4%)	(104.9%)
CKNP	127 ab	236 ab	204 a	567 a	22.49abc	65.99ab	58.88a	147.79a	17.59cd	27.85ab	28.89b	26.05b
	(100.0%)	(100.0%)	(100.0%)	(100.0%)	(100.0%)	(100.0%)	(100.0%)	(100.0%)	(100.0%)	(100.0%)	(100.0%)	(100.0%)
BMP	119 abc	217 bc	150 b	486 b	25.53ab	56.99b	42.63b	125.13b	21.53b	26.32ab	28.52b	25.83b
	(93.1%)	(91.6%)	(73.4%)	(85.4%)	(113.5%)	(86.4%)	(72.4%)	(84.7%)	(122.4%)	(94.5%)	(97.6%)	(99.2%)
BNP	114 bc	192 c	119 c	425 b	23.83a	55.10b	36.54b	120.56b	25.18a	28.64ab	30.69ab	28.36a
	(89.6%)	(81.2%)	(58.6%)	(74.9%)	(128.2%)	(83.5%)	(62.2%)	(81.6%)	(143.1%)	(102.8%)	(106.2%)	(108.9%)
DMP				646 a (113.8%)				156.84a (106.1%)				24.32b (93.4%)
DNP				622 a (109.9%)				157.05a (106.3%)				25.25b (97.0%)

[1] See Table 1 for description of treatment abbreviations.

、套袋6—10日（BMP與BNP）及套袋3—5日(DMP與DNP)皆有延長效果，充實穗長介於14.99—17.10cm之間，較對照（CKNP）之13.49cm增長11.1—26.8%。

再將8項處理區分爲4組，顯示是否輔以人爲授粉並不影響有關穗長各項性狀之表現（表2），組內間之差異皆未達顯著水準，亦即各處理如可增加充實與全穗長，或減少不充實穗長，並非人爲輔助授粉之效果。

表3爲玉米果穗上、中、下部位之穗周與軸周長度比較。穗周與軸周皆自果穗上端至下端逐漸增加，以對照（CKNP）處理爲例，上、中、下位之穗周分別爲10.32、14.87與15.81cm，軸周爲7.37、9.07與10.09cm（各佔穗周之71.4%、61.0%與63.8%）。降低族羣密度兩處理中，輔以人爲授粉（TMP）可增加上位穗周（增幅12.7%），自然授粉（TNP）處理則降低上位軸周（降幅 3.4%）；套袋6—10日處理（BMP與 BNP）可增加上位穗周（11.0—17.2%）與軸周（8.4—11.1%），但減少中、下位穗周（ 5.7—14.0%）與下位軸周（5.2—6.5%）；套袋3—5日之處理效果不明顯，僅DNP（自然授粉）可顯著增加上位穗周（12.6%）。

人爲輔助授粉與否對穗周與軸周之影響亦不明顯，4組處理中僅於降低族羣密度處理內，人爲授粉（TMP）較自然授粉（TNP）有較大的上位穗周，其餘所有之差異均未達顯著水準。

子粒數目與重量爲決定單穗產量之要素，表4資料顯示對照（CKNP）處理之一穗粒數爲567粒，上、中、下位之粒數各爲127、236與204粒，分別佔總數之 22.4、41.6與36.0%。降低族羣密度與自然授粉處理（TNP）可減少上位子粒數，套袋6—10日處理（BMP與BNP）則減少下位粒數與總粒數，其中BNP處理（自然授粉）並使中位粒數降低。其他各處理或各部位之差異則均不顯著。

在粒重方面，對照處理之一穗總重爲 147.79g，上、中、下位之粒重分別爲 22.49、65.99與58.88g，亦即三個部位對產量之貢獻爲15.2、44.7與40.1%。各處理對一穗粒重之影響多不顯著，僅

Table 5. Correlation coefficients among some ear characters of Tainung 351 maize[1]

Characters[2]	V1	V3	V4	V5	V6	V7	V11	V12
V2	0.78							
V3	− 0.70							
V4		0.95						
V5	− 0.69	0.60						
V6	0.56	− 0.65	− 0.57					
V7	− 0.65	0.74	0.65	0.76	− 0.50			
V8	− 0.66	0.75	0.67	0.84	− 0.68	0.75		
V9	0.62				0.86	− 0.68	0.76	0.95
V10					0.83		0.86	0.80

1 Only significant Correlations ($P \leq 0.05$) were shown.
2 V1: length of unfilled part of ear.
V2: length of nonfertilized part of ear.
V3: length of filled part of ear.
V4: total length of ear.
V5: periphery of ear tip.
V6: periphery of ear base.
V7: periphery of cob tip.
V8: weight of tip kernels.
V9: weight of basal kernels.
V10: total weight of kernels.
V11: number of middle kernels.
V12: number of basal kernels.

套袋 6—10日處理(BMP與BNP)可降低下位粒重(降幅27.6—37.8%)與總粒重(降幅15.3—18.4%)；BMP、BNP 與 TMP（降低族羣密度及人爲授粉）處理有使上位子粒重量增加的趨勢（13.5—28.2%），但統計分析則未達顯著水準。

百粒重之資料亦列於表 4，對照處理（CKNP）上、中、下位子粒之百粒重分別爲17.59、27.85與 28.89g，平均爲 26.05g，亦以上位子粒最輕，中、下位子粒較重。套袋 6—10日處理（BMP與BNP）可大幅增加上位子粒之百粒重，增幅高達22.4—43.1%，其中 BNP處理（自然授粉）之全穗平均百粒重並因而提高8.9%；降低族羣密度與自然授粉處理（TNP）可使下位與全穗平均百粒重增加約12%，又使上位子粒百粒重有升高的趨勢，唯後者未達顯著水準。

對部份調查性狀間之相關分析資料列於表 5，就穗頂不充實部份之長度而言，與不稔實穗長呈極顯著之正相關（r＝0.78），與上位穗周及軸周呈極顯著負相關（r＝－0.69及－0.65），與上位粒重呈負相關（r＝－0.66）但與下位粒重則有正相關關係存在（r＝0.62）。

充實穗長與全穗長呈極顯著正相關（r＝0.95），其上位穗周與軸周亦愈粗大，且上位粒重與百粒重愈重；但充實穗長却因下位穗周與軸周之增大而縮短，有負相關關係存在在（表 5）。

全穗長與下位穗周呈顯著負相關而與上位穗周、軸周及粒重呈顯著正相關。中位與下位粒數之增加皆可使一穗子粒重量（產量）提高，有顯著之正相關關係存在（表 5）。

表 6 爲成熟期玉米上、下位子粒與穗軸內全氮與 TNC濃度。就上位子粒之全氮濃度而言，族羣密度減半及人爲授粉處理（TMP）最低（1.52%），但族羣密度減半及自然授粉（TNP）者最高，達1.70%，其餘各處理（含對照）間之差異不大，均爲1.60—1.63%。下位子粒全氮濃度則以對照處理（CKNP）最低（1.59%），TMP 及 TNP分別爲1.61與1.76%，套袋 6—10日處理（BMP與BNP）較高，介於1.81—1.87%之間。

Table 6. Concentrations (%, dry weight basis) of N and total nonstructural carbohydrates (TNC) in kernels and cob of Tainung 351 maize as affected by various treatments

Treatment[1]	Kernel (N)		Cob (N)		Kernel (TNC)		Cob (TNC)	
	Tip	Basal	Tip	Basal	Tip	Basal	Tip	Basal
TMP	1.52	1.61	1.15	0.43	81.26	80.36	19.62	10.72
TNP	1.70	1.76	1.27	0.33	83.63	83.70	20.37	13.64
CKMP	1.63	1.65	1.21	0.32	78.00	79.12	16.33	8.78
CKNP	1.60	1.59	1.13	0.29	82.90	83.15	15.42	9.94
BMP	1.63	1.87	0.69	0.46	81.29	82.95	16.47	11.88
BNP	1.63	1.81	0.63	0.43	81.22	79.56	13.63	10.86

[1] See Table 1 for description of treatment abbreviations.

上位穗軸之全氮濃度除以 BMP與BNP處理較低（分別爲0.69與0.63%）外，其餘各處理相近，介於1.13—1.27%之間（表 6）。下位穗軸之濃度則顯著低於上位穗軸之濃度，均在 0.5%以下，對照（CKNP）僅爲0.29%，族羣密度減半處理（TMP與TNP）爲0.33—0.43%，套袋 6—10日處理（BMP與BNP）爲0.43—0.46%，後者有較高的趨勢（表 6）。

在TNC濃度方面，除BMP與BNP一組處理外，均有自然授粉較人爲授粉爲高的表現；族羣密度減半時，自然受粉處理（TNP）上位子粒之 TNC濃度爲88.63%，下位子粒爲83.70%，而人爲授粉處理（TMP）則分別爲81.26%與80.36%；又對照組自然授粉處理（CKNP）上、下位子粒濃度爲

82.90%與83.15%，人爲授粉處理（CKNP）分別爲78.00%與79.12%（表6）。

處理間穗軸TNC濃度有明顯的差異，對照（CKNP）處理上位穗軸的濃度爲15.42%，族羣密度減半處理（TMP與TNP）則高達19.62—20.37%，BNP（套袋6—10日及自然授粉）最低，僅爲13.63%。下位穗軸TNC濃度均較上位穗軸爲低，對照（CKNP）爲9.94%，TMP與TNP處理略高，分別爲10.72%與13.64%，BMP與BNP處理則爲11.88%及10.86%（表6）。

討　論

試驗期間對臺農351號玉米穗頂進行詳細觀察，發現穗頂不充實現象可分爲以下四個類型：

1. 穗軸頂端發育不良而萎縮。
2. 穗軸之發育正常，但頂端穎花未能受精。
3. 穗軸頂端發育正常且穎花受精，但子粒不能充實。
4. 以上三種類型之混合型。

推測玉米穗頂不充實之原因可概分爲遺傳與生理因素二大項，；遺傳因素屬品種特性，生理原因則涵蓋甚廣；本試驗各項處理包括降低族羣密度，以增加供源葉片之光合成能力，又套袋6—10天抑制部份中、下位子粒發育，以減少積儲容積，以及套袋3—5日延遲中、下位穎花之受精時間，以減少上位子粒與中、下位子粒在競爭養份能力方面的差異，此外，並配合人爲輔助授粉，檢討花粉供應問題，藉以探究可能影響臺農351號玉米品種穗頂子粒不充實的生理原因。茲針對以上各處理，分項討論如下。

一、玉米子粒充實期間光合成物質之供需平衡關係：

許多學者認爲玉米產量，尤其是溫帶玉米產量，主要受供源能力的限制（source limiting）[15,17,25]，因而建議擴大行株距以增加族羣光線穿透效率[26]、改變族羣結構以提高族羣下位葉片之受光度[6,18,25]，及去除雄穗以避免遮蔭效果[7,13]，均可增强供源能力而提高產量。

本試驗於玉米吐絲期間拔行內植株，使密度減半爲每公頃29,400株（TMP與TNP處理），結果使穗頂不充實部份長度減爲2.73—3.11cm，爲對照（CKNP）處理（3.39cm）之80.5—91.7%，似有減輕穗頂不充實現象之效果（表2）；但由於一穗粒數與百粒重並未顯著增加，故對提高產量並無助益（表4），亦即在此一試例中，減輕臺農351號玉米穗頂不充實程度並不能達到顯著增產的目的。

由表1之資料得知，TMP與TNP處理成熟期之全株乾重均有增加，後者並達顯著水準，但與對照（CKNP）比較，所增加之乾物質多累積於莖稈、苞葉或穗軸，對產量並無影響，應爲乾物質轉流與分配效率的結果。此外，由吐絲至成熟期間，對照處理玉米植株營養器官之乾物重仍持續增加，顯示此一期間之光合成物質生產足供子粒充實之需，不必依靠預貯物質之再轉流供應。又對照處理上位穗軸TNC濃度雖較TMP與TNP處理略低，但仍高達 15.4%（表6），表示仍有多量碳水化合物未爲子粒利用。由以上結果可知限制臺農351號產量之因子應爲積儲容積，而非供源能力；且降低族羣密度可減輕穗頂不充實程度之現象，亦可能爲次級效應（secondary effect）所產生的結果。

二、穗內子粒發育與充實之時序差異：

Bonnett[3]指出玉米雌穗上穎花之分化是由基部至頂端之方向（acropetal)依序完成；Frey[10]認爲頂端穎花之發育最遲而最後受精，子粒開始充實的時間亦較晚；Nishikawa and Kudo[16]更指出穗部頂端部份穎花是無法發育的，部份穎花雖可受精，但子粒充實在早期即已停止。上述原因均可能影響穗頂充實問題，故應針對臺農351號之特性加以檢討。

本試驗於吐絲始期將雌穗套袋3—5日，目的在延緩下位穎花之受精時間，縮小與上位穎花受精時間之時序差異，但又不影響其子粒充實，結果處理效果甚爲理想。DMP與DNP兩處理可將穗頂不充實部份長度減少至2.29—2.60cm，僅爲對照（CKNP）植株之67.7—76.7%，佔全穗長之12.8—

14.8%，亦低於對照處理（20.1%），效果極爲明顯（表２）；又上位穗周長度增加10.9—12.6%，而軸周則與對照相近（表３），顯示上位子粒之發育可能較爲良好；在一穗總粒數方面，增幅爲 9.6—13.8%，產量提高６%左右（表４），唯均未達顯著水準。本試驗缺少果穗上、中、下部位子粒數、粒重及百粒重資料，但由以上結果及 Bagnara and Daynard[2] 報告延遲授粉可使頂端三分之一部位粒重顯著增加之結論推測，頂端子粒可能亦有較高之粒重與百粒重。

根據延遲授粉處理（即DMP與DNP）試驗結果，得知中、下位子粒之發育與充實可影響上位子粒，甚至穗軸之分化與發育，與穗頂不充實現象有關，但與最終產量間之關係則仍不明確。此外，並根據上述結論提出假設，認爲如能自同一時間開始發育與充實，則可減少上位子粒與下位子粒對供源利用能力之先天差異，有助於提高上位子粒之充實程度。有關穗內不同部位子粒之養份需求競爭作用，及與花絲抽出時間及花粉供應間之關係，將於以下敍述討論。

三、玉米穗內不同部位之養份需求競爭作用：

穗內不同部位穎花由於分化時序等之差異，可導致上位子粒具有較弱之積儲强度(sink strength)[19,21]，因此其直線充實期發生較晚，爲時亦短[22]，子粒重量亦較輕[10]。許多報告並指出玉米穗頂子粒胚乳細胞數目因而較少[11,24]，體積較小[14,22]，其內之澱粉粒亦較小[14]，且胚乳細胞內利用蔗糖之酵素活性較低[11]，均爲可能導致穗頂子粒充實不良之基本原因。

Tollenaar and Daynard[22] 發現吐絲後 10日去除部份下位子粒可以促使所有頂端子粒充實，本試驗因而擬定將雌穗套袋６—10日之處理（BMP與 BNP），減少中、下位子粒數目，降低其積儲容積與强度，探討對臺農 351號玉米穗頂充實問題的影響。

BMP與 BNP 處理可增加全穗長（13—14%）及充實穗長（24.5—26.8%），減少不充實穗長(29.8—37.2%)（表２），增大上位穗周（11—17%）及軸周（８—11%）（表３），減少中、下位子粒數目（８—41%）（表４），顯示處理效果甚爲明顯，尤以提高上位子粒之百粒重達22—43%及粒重達13—28%（表４），較 Tollenaar and Daynard[22] 之結果更爲顯著。但兩項處理並未能增加上位子粒之數目，且就實際應用價值而言，由於總粒數大幅減少，產量亦因而降低（表４）。

上述結果顯示，臺農 351號玉米品種上位子粒利用養份之能力，因受到中、下位子粒之强烈競爭而有不足，此固爲穎花分化時序差異之直接結果，但也可能受到中、下位子粒完全充實後釋放老化訊息，進而阻礙養份轉流之影響，均足以造成上位子粒發育不良及穗頂不充實等現象。

四、花粉供應及抽穗與吐絲時間差異之作用：

抽穗與吐絲時間差距較大，以致花粉供應不足，常被認爲是臺農 351號玉米穗頂不充實的重要原因之一，但尚無試驗資料可供證明。依據Buren *et al.*[4]、Dow *et al*[6] 及Muleba *et al.*[15] 等之報告，抽穗與吐絲時間差距之長短與產量有密切關係；如縮小此一差距，可減少不結實粒數，使上位粒重顯著升高[2]。有關臺農351號之試驗結果， Wang *et al.*[23] 發現抽穗與吐絲期之間隔最多可達９日，全省玉米栽培試驗綜合報告（未發表）爲３—８日。本試驗則發現雄穗抽出後２日開花，再隔４日（變域爲１—８日）吐絲，但吐絲期較長，最多可達14日，因此穗頂花絲抽出時，花粉供應不足之情況亦屬可能。 Buren *et al.*[4] 即曾指出，花絲迅速抽出可與花粉散落時間配合而提高產量，此一特性亦因品種不同而呈現差異。

此外，臺農 351號玉米品種之粒數多，繁密之花絲可能因相互遮蔽效應而影響授粉。田間觀察發現臺農351號玉米花絲之露出長度可達 10cm 以上，一般亦在 6cm左右，是否影響花粉之有效性，亦爲值得考慮的問題。

本試驗在所有處理中均增設配合人爲輔助授粉處理（TMP、CKMP、BMP及DMP），而與對照（CKNP）比較，亦多能達到縮短不充實穗長之顯著效果（表２）；但在任一處理內比較人爲授粉與否之結果，却又未能發現顯著性差異，亦即各處理如可減少不充實穗長，似非源由於人爲授粉之作用；唯表２資料顯示，所謂「不充實」穗長主要係由不稔實（未受精）部份構成，兩者之間具有極顯

著之正相關（表 5），子粒充實不良的影響反而較小，因此似又不能否定花粉供應不足或授粉機制受到阻礙的重要性，其確實原因尚待檢討。

El-Lakany and Russell[9] 報告增大玉米族羣密度可能延長開花至吐絲期之間隔；Anderson *et al.*[1] 指出提高N肥用量可以縮短吐絲期，使子粒提早受精與充實而增產。可否以栽培方法調節臺農351號玉米開花與吐絲期，以減低穗頂不充實程度，尚待進一步研究。

五、遺傳因素——品種特性：

Daynard and Duncan[5]、Egharevda *et al.*[8] 及Hanway[12] 等均曾報告玉米穗頂子粒發育不良，顯見穗頂不充實並非臺農 351號玉米品種獨有之特性，值得注意者應係程度上之差異及對產量之影響。

依據本所玉米研究室的報告（未發表），臺農351號穗頂不充實現象是由父本TA80—1410遺傳而來。本試驗所採用之材料包括臺農育121品系（試驗結果將以另文發表），與臺農351號具有相同母本及不同父本；臺農育121號穗頂不充實程度極爲輕微，長度僅0.82cm，佔全穗長（18.4cm）之4.5%，幼穗頂端穎花之發育優於臺農351號，產量亦較高。臺農351號不充實穗長(CKNP處理）爲3.39cm，佔全穗長之20.1%，各種處理雖可減輕其程度，但不充實現象仍然存在，長度爲 2.13—3.00cm，爲總穗長之11.1—18.2%，且對產量沒有顯著影響，因此穗頂不充實可能爲臺農 351號玉米一項品種特性。綜合本試驗結果，臺農 351號玉米穗頂不充實現象依其表現可分爲四種類型，在推論屬於品種特性之基礎上討論其發生原因，應與花粉供應、授粉機制、穗內穎花發育與子粒充實之時序差異，以及子粒間競爭養份能力有關；光合成物質之生產與供應並無不足，但養份向穗頂子粒之運送可能受到阻礙，使子粒不能完全充實。就臺農 351號品種而言，穗頂充實與否與產量間之關係並不明確，對照（CKNP）處理之子粒產量高達 8.7t/ha，不充實穗長仍佔全穗長之20%，其他處理雖可減輕穗頂不充實長度與比率，但對產量並無影響。臺農 351號爲一具有高產潛力之品種，粒數對產量之重要性大於粒重（表 5），因此在現階段應由適當的栽培方法達到高產的目的，而不必過於强調穗頂不充實現象對此優良品種產量的影響；在今後繼續改良玉米品種的過程中，應可經由選擇適當親本與選拔技術而克服此一外觀上的缺失。

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Studies on the Causes of Ear-tip Unfilling of Tainung 351 Maize[1]

C. S. Wang, S. H. Tsao and D. J. Liu[2]

Summary

One weakness of the high-yielding, single-cross maize hybrid Tainung 351 is the poor development of the ear tip. Four different types have been observed: (1) deterioration of the ear (cob) tip, (2) non-pollination of tip spikelets, (3) unfilling of tip kernels and (4) mixed type. Average length of the unfilled portion was 20% of total ear length. However, grain yield as high as 8.7t/ha was recorded. Treatments of this experiment included thinning the stand to half the original density, bagging the ear for 3—5 or 6—10 days to delay pollination or restrict the development of basal kernels, respectively. Characteristics of kernels on different parts of the ear (tip, middle and basal) at harvest were measured and concentrations of total nonstructural carbohydrates (TNC) and N were also analyzed. Measures for improving the filling of tip kernels were discussed.

Factors resulted in the ear-tip unfilling can be deduced from the experimental results as follows: (1) differentiation and development of tip spikelets were later than those of the middle or lower ones, and hence the tip kernels possessed smaller sink strength, (2) the interval between anthesis and silking and the extended period of silking rendered the tip spikelets unpollinated due to lack of pollen source. The long silks might also produce shading effect in preventing the tip spikelets from receiving pollens, and (3) competition of nutrients or even inhibition from the basal and middle kernels on the tip kernels. The latter hypothesis was supported by the fact that 100-kernel-weight of the tip kernels could be increased significantly by restricting the development of basal kernels through bagging the ear for 6—10 days at silking stage. Based on the results of changing dry weight and TNC concentrations in different plant parts during kernel filling, it was concluded that sink strength of the ear-tip, rather than the source capacity, was the reason for the unfilling. In fact, it was found that limiting factor for the yield of Tainung 351 maize was in the sink end. The supply of photosynthates exceeded those needed by the developing kernels.

All the treatments in this experiment showed effect in reducing the degree of ear-

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tip unfilling. However, the unfilling portion still occupied 11—18% of the ear length. It is possible that this character might be genetically inherent. Furthermore, the relationship between ear-tip unfilling and grain yield of this specific hybrid is not clear. As many factors are considered important in causing the poor development of the ear tip, it might be more practical to improve the cultural methods to increase the yield of the high-yielding Tainung 351 maize before varieties with well-developed ear tip have been released.

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熱帶地區大蒜健康種苗培育技術之研究

林　昭　雄

摘要：大蒜為臺灣重要內外銷蔬菜之一，由於多年來無性繁殖關係，大蒜嵌紋毒素病之發生，已甚為普遍，對產量及品質之影響鉅大。必須加速培育大蒜健康種苗以為挽救。

利用大蒜莖頂生長點組織培養繁殖無病毒之健康苗為避免大蒜毒素病發生之有效方法之一，但此法費工費時，成本甚高，目前已克服許多困難，已從試管培育至第五代之組織培養苗。經生物病毒檢定結果，平均可獲得52.10%之無病毒級種苗，21.01%之微病毒級種苗。品種方面，白葉種比黑葉種之感毒素病性較大。

一般商業用種瓣含病毒很高，屬於重病毒級植株達 83.33%，但其珠芽苗所含之病毒較少，無病毒級佔7.14%，微病毒級有 21.43%，而且珠芽大小相當於第２～３代之組織培養種球，如配合適當之熱療使微病毒級或輕病毒級之組織培養種球或珠芽之病毒不活化，而加以利用，可減低大蒜健康種苗之培育成本。

熱療處理雖無法除去病毒，但對病毒之不活化有效。如採用熱水熱療以 48～50°C 熱水處理15分鐘為宜，54°C 處理15分鐘發芽會減低40%，而 54°C 熱水處理30分鐘為大蒜蒜瓣熱水熱療之致死溫度與時間。如採用熱風熱療則以 40°C 熱風處理蒜球70天，蒜瓣60天為宜。

大蒜（Allium sativum）屬於石蒜科之重要蔬菜，除可供青蒜、蒜苔、蒜球作新鮮蔬菜外，尚可加工製成蒜片、蒜粉或油精等。目前臺灣地區大蒜栽培面積達12,265公頃，生產量 124,740公噸，價值７億８千萬元[8]，為臺灣之重要內外銷蔬菜之一。大蒜病害甚多，有真菌性的黑斑病 Purple leaf spot（Alternaria porri），銹病（Puccinia allii），菌核病 Sclerotinia rot（Sclerotinia spp.）黑黴病 Black mould（Mycosphaerella schonoprasi），細菌性軟腐病 Erwinia rot（Erwinia spp.）及毒素病 Virus diseases（Garlic mosaic virus, garlic latent virus, onion yellow dwarf virus, tabcco mosaic virus）等，其中以大蒜嵌紋病最為普遍[5]。

Brierley 與 Smith（1944）報告所有栽培大蒜幾乎全部罹患嵌紋病[13]，Havranek（1972）也報告嵌紋病毒能造成鱗莖蒜球減產32—45%[14]，韓國羅氏（1973）報告韓國之大蒜幾乎全部感染病毒[21]，在臺灣大蒜多年來因連作及無性繁殖關係，品種方面已有退化現象，加上臺灣位於熱帶地區毒素病之罹病率頗高，帶毒植株甚為普遍[5]，周氏（1975）調查臺灣栽培之大蒜具嵌紋病徵者高達100%，且遍布全省，罹病植株在葉脈間形成嵌紋濃綠與淺黃線條之斑紋，生育不良，形成鱗莖變小[6]，目前大蒜毒素病已嚴重影響品質及產量，有加速培育健康種苗種植之必要。

在植物病理學上，利用生長點組織培養無病毒苗，以達防治毒素病之目的已有成功實例[20,29]。有關大蒜之莖頂生長點組織培養亦有人嘗試[3,9,14,]惟尚未達實用化階段。近年來作者（1982）在鳳山熱帶園藝試驗分所隔離網室內從事大蒜組織培養苗培育工作，發現由大蒜莖頂生長點培養之幼苗甚為

1.臺灣省農業試驗所　研究報告第 1231號。

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纖細，由試管移植後之培育與繁殖甚不容易，要培育成為普通可種植之種瓣大小，費工費時，目前雖已克服許多困難，培育至第五代組織培養苗 [5]。惟初步利用指示植物藜（Chenopodium amaranticolor）作生物檢定結果，尚有部分出現局部病斑（Local lesion），顯示利用大蒜莖頂生長點之培育，只能獲得低病毒之種苗。同時單株取樣接種作生物病毒檢定，增加生產成本甚高。因此，除培育完全無病級（Virus free grade）種苗外，是否能就低病毒種球或一般珠芽（Bulbil）配合熱療（Heat therapy）或化學藥劑處理供作低病毒級（Low titre grade）種苗之可行性加以探討，期能早日實用化。

材料與方法

一、臺灣大蒜毒素病發生情形調查

於大蒜栽培期間到本省主要大蒜生產地區如伸港、莿桐、麥寮、學甲等地逢機取樣調查大蒜毒素病發生情形。每地區調查 5 區，每區隨機調查200株。依據病徵出現程度將發病等級分為 M_0：無嵌紋病徵株，M_1：葉片面積一半以下具嵌紋病徵株，M_2：葉片面積一半以上具嵌紋病徵株，Y：黃萎病徵株等四級求其發病率。並將無嵌紋病徵之大蒜葉片取樣做病毒之生物檢定，究明是否無病毒植株。

二、栽培品種與大蒜毒素病之關係

於大蒜生育後期，就鳳山熱帶園藝試驗分所蒐集保存的大蒜品種中，選擇臺灣主要栽培品種作調查。各品種逢機取樣 200株調查大蒜毒素病發生情形。依據病徵出現程度將發病等級分為 Mo, M_1, M_2, Y 等四級，求其罹病性差異。並將無嵌紋病徵之大蒜葉片取樣做病毒之生物檢定，究明是否無病毒植株。

三、大蒜試管苗之培育：

將鳳山熱帶園藝試驗分所之鳳選一號，鳳選二號大蒜品種之蒜瓣，經超音波洗淨器（Ultrasonic cleaner）洗淨表面，再經75%之酒精行表面消毒，然後在 8 ～32倍之解剖顯微鏡下切取高約 300μ 之莖頂生長點圓錐體（Shoot apical dome）置於適宜的培養基上作試管無菌培養，培育大蒜試管苗。試管苗材料由中央研究院植物研究所供給 [3]，鳳山熱帶園藝試驗分所將試管內之大蒜苗體移至隔離網室內經消毒過之最適培養土中，細心培育組織培養苗第一代、第二代、第三代、第四代 [5] 及第五代。生長點培養所得之植株葉片均不具嵌紋病徵，但為判定有無病毒，仍以指示植物——藜（Cheno podium amaranticolor）作病毒之生物檢定。

四、大蒜嵌紋病毒的生物檢定：

將供試大蒜植株之葉片分別加上 5 倍量 0.1M 磷酸緩衝液（phosphate buffer）pH7.0 在消毒過的研磨鉢中研磨，研磨後再用兩層紗布過濾，以此過濾液作為接種源接種到健全之指示植物藜（chenopodium amaranticolor）葉上作為檢定之用 [1,7,10]。

接種之前去帶紅色素的心葉，側芽及最底部的二葉。全葉接種，採用拉丁方設計（Latin square design）。接種前在其葉片上均勻撒布一層 600 mesh 金剛砂（Carborundum）以沾有接種源之棉花或玻璃小棒在葉片上輕輕擦拭，然後以自來水冲洗葉表面，除去殘留的金剛砂。接種後一週、二週、三週、定期分別調查接種葉上所形成之局部病斑（Local lesion）數目，間接測定病毒之相對感染力或濃度 [7]。

五、大蒜嵌紋病之不活化試驗

本研究分別以㈠物理的治療法——熱療處理，㈡化學的治療法——藥劑處理，㈢生物的治療法——生長點組織培養等三種方法或作配合處理來探討大蒜嵌紋病毒之不活化情形及尋求最經濟實用之方法。其中藥劑處理部分，將另文討論，組織培養則述於本文結果與討論第五項。

熱療法（Heat therapy）分熱水熱療處理（Hot water treatment）與熱風熱療處理（Hot air

treatmant）兩種。

熱水熱療處理分兩次進行，第一次於民國70年1月28日，以5種溫度 52, 54, 56, 58, 60°C 及4種時間 15,30,45,60 分鐘組合成20個處理。第二次於民國70年11月11日以6種溫度 48, 50, 52, 54, 56, 58°C及3種時間15,30,45分鐘組合成18個處理，兩次均以 20°C 水溫浸30分鐘爲對照處理（如表3.4）每處理20枚蒜瓣。

熱風處理在溫度 40°C 之定溫箱內，時間分40.50.60.70天等四處理，供試材料再分蒜球(Bulb)及蒜瓣（Clove）兩種處理（如表6），所用品種爲鳳選二號。

70年2月5日於田間大蒜植株上接種 GMV 病毒，70年4月採收蒜球貯藏，8～10月間行 40°C 熱風熱療處理，11月種植於隔離網室內，71年2月2日將接種種源取樣稀釋5倍液接種於藜（Chenopodium amaranticolor）指示植物葉片上，每處理5葉片（五重複）採拉丁方設計排列。

以上各實驗處理後將供試材料栽植於隔離網室內，調查其發芽情形及生長情形（株高、葉數）並在供試植株之葉片抽樣接種到指示植物上，做大蒜嵌紋病毒的生物檢定，調查接種葉上形成之局部病斑消長情形，探討各處理對大蒜嵌紋病毒之不活化效果比較，並判定供試種蒜爲無病毒級（Virus-free grade）或低病毒級（Low titre grade）種苗。

結果與討論

一、臺灣大蒜毒素病發生情形調查：

於大蒜生產期間至臺灣大蒜栽培地區包括莿桐、仲港、麥寮、學甲等地區抽樣調查大蒜毒素病發生情形結果如表1所示。莿桐地區莿桐白葉品種平均發生黃萎病 0.75%，輕微大蒜嵌紋病徵者12.75%，嚴重大蒜嵌紋病徵者4.50%，無大蒜嵌紋病徵者有82%。仲港地區仲港黑葉品種平均發生黃萎病1.63%，輕微嵌紋病者20.62%，嚴重嵌紋病者9.13%，無嵌紋病徵者68.62%。麥寮地區硬骨黑葉品種輕微嵌紋病株有61.75%，嚴重嵌紋病徵株有36.75%，無嵌紋病徵株僅爲1.25%。一般言大蒜毒素病可分黃萎病（Yellow dwarf）與嵌紋病（Mosaic）兩種，前者感染後植株顯著矮化，葉變黃而萎縮，不結大球，完全無收穫，影響產量及收益甚大，所幸發病率僅在0～3.50%之間，佔極少比率。後者感染後植株葉片呈現濃綠與淺黃線條之嵌紋病徵，減低光合作用，影響單球之肥大，對大蒜蒜球品質及單位面積產量之影響鉅大。葉片嵌紋病徵愈多光合作用愈降低，蒜球大小或單球重愈小，據調查結果顯示，輕微嵌紋病株（葉片面積¼具嵌紋病徵）比無嵌紋病徵株者單球重減低約20%，嚴重嵌紋病株（葉片面積½具嵌紋病徵）比無病徵株者單球重減低約30% [5,6]，因此吾人可根據大蒜毒素病病徵發生情形而預估蒜球之產量，而且如能培育無病毒種蒜種植，則可大大提高大蒜之單球重及品質。

二、栽培品種與大蒜毒素病之關係：

臺灣地區大蒜地方品種繁多，且均有退化現象，尤其毒素病之發生情形差異甚大，本分所蒐集之大蒜品種與毒素病之罹病性之關係，經詳細調查，其結果如表2所示。本試驗供試調查23品種，均未發現黃萎病株（Y）。無嵌紋病徵株（M_0級）平均24.52%，輕微嵌紋病徵株（M_1級）平均達68.79%，而嚴重嵌紋病徵株（M_2 級）平均亦達6.69%。

就品種間之差異而言，安南蒲蒜品種 M_0 級（無嵌紋病徵）僅8.50%，西螺南興硬骨大白葉品種僅11.00%，溪州硬骨黑葉品種僅12.50%，爲罹病性較高之品種。而莿桐硬骨大黑葉品種 M_0 級爲38.50%，二崙硬骨黑葉品種 M_0 級爲38.50%，學甲硬骨大黑葉品種爲38%，爲罹病性較低品種。

就黑葉與白葉種來比較，白葉種之感病性較大（表2）莿桐硬骨大黑葉品種 M_0 級 38.50%，而莿桐硬骨大白葉品種 M_0 級僅爲29.50%，二崙硬骨黑葉品種 M_0 級爲38.50%，二崙硬骨大白葉品種 M_0 級僅爲 26.00%，西螺公館硬骨大黑葉品種 M_0 級爲 31.62%，西螺南興硬骨大白葉 M_0 級僅爲11.00%。

表1. 臺灣大蒜生產地區毒素病發生情形調查

Table 1. The occurrence of virus diseases in Taiwan garlic production areas.

調查地區 Locality	栽培品種 Cultivar	種植日期 Date Planted	調查日期 Date investigated	大蒜毒素病株(%) Garlic virus diseased plants			
				M_0	M_1	M_2	Y
莿桐 A	莿桐硬骨白葉	71.10. 1	72. 1.27	82.50	12.50	5.00	0
莿桐 B	莿桐硬骨白葉	71.10.15	72. 1.27	87.00	10..00	3.00	0
莿桐 C	莿桐硬骨白葉	71.11. 5	72. 1.27	80.00	13.50	5.00	1.50
莿桐 D	莿桐硬骨白葉	71.11.20	72. 1.27	78.50	15.00	5.00	1.50
莿桐地區平均	莿桐硬骨白葉	—	72. 1.27	82.00	12.75	4.50	0.75
伸港 A	伸港硬骨黑葉	71.11.18	72. 3. 4	56.50	27.50	12.50	3.50
伸港 B	伸港硬骨黑葉	71.10.20	72. 3. 4	60.50	25.50	11.50	2.50
伸港 C	伸港硬骨黑葉	71.10.31	72. 3. 4	77.50	15.50	6.50	0.50
伸港 D	伸港硬骨黑葉	71.10.29	72. 3. 4	80.00	14.00	6.00	0
伸港地區平均	伸港硬骨黑葉	—	72. 3. 4	68.62	20.62	9.13	1.63
麥寮 A	麥寮硬骨黑葉	71.10.20	72. 3.10	2.50	54.50	43.00	0
麥寮 B	麥寮硬骨黑葉	71.10.24	72. 3.10	0	69.00	30.50	0.50
麥寮地區平均	麥寮硬骨黑葉	—	72. 3.10	1.25	61.75	36.75	0.25
學甲 A	學甲花蒜	71.10.15	72. 3.10	74.00	19.50	6.50	0
學甲 B	學甲花蒜	71.10.18	72. 3.10	73.00	20.00	6.00	1.00
學甲地區平均	學甲花蒜	—	72. 3.10	73.50	19.75	6.25	0.50

註：1.發病等級：M_0 ：無嵌紋病徵株

M_1 ：葉片面積一半以下具嵌紋病徵株

M_2 ：葉片面積一半以上具嵌紋病徵株

Y ：黃萎病株

2.百分率爲各地區調查200株之平均值

此等以肉眼觀察爲無嵌紋病徵植株(Symptomless plant)並不一定爲無病毒植株(Virus-free plant)。由肉眼觀察無嵌紋病徵之植株取樣葉片進行大蒜嵌紋病毒之生物檢定，結果在指示植物藜葉片上均有局部病斑(Local lesion)出現。顯示無嵌紋病徵植株並非無病毒植株，或可能爲大蒜潛在病毒(Garlic latent virus)。

表2. 大蒜栽培品種對毒素病感病性之反應

Table 2. Reaction of cultivars to the susceptibility of garlic virus diseases

品種名稱	大蒜毒素病株 Garlic virus diseased plant (%)			
Cultivar	M_0	M_1	M_2	Y
鳳選一號（硬骨大葉）	21.00	67.00	12.00	0
鳳選二號（硬骨黑葉）	25.50	68.00	6.50	0
莿桐硬骨大黑葉	38.50	54.00	7.50	0
莿桐硬骨大白葉	29.50	62.50	8.00	0
二崙硬骨黑葉	38.50	57.00	4.50	0
二崙硬骨大白葉	26.00	65.00	9.00	0
西螺公館硬骨大黑葉	31.62	66.30	1.75	0
西螺南興硬骨大白葉	11.00	75.50	13.50	0
伸港硬骨黑葉	32.50	63.00	4.50	0
溪州硬骨黑葉	12.50	75.00	12.50	0
虎尾硬骨大黑葉	38.00	61.00	1.00	0
麥寮硬骨大黑葉	13.50	81.50	5.00	0
安南蒲蒜（硬骨大黑葉）	8.50	79.00	12.50	0
學甲硬骨大黑葉	38.00	55.50	6.50	0
學甲軟骨	21.14	73.60	5.26	0
學甲花蒜（軟骨大白葉）	38.00	59.00	3.00	0
巴　西（硬骨大葉）	19.00	73.50	7.50	0
秘　魯（硬骨大葉）	26.00	72.00	2.00	0
優D（硬骨大黑葉）	15.00	83.33	1.67	0
G 8（硬骨大黑葉）	27.50	68.00	4.50	0
50—34（硬骨大葉）	22.00	72.50	5.50	0
S—8（硬骨大葉）	11.67	74.16	14.17	0
S—5（硬骨大黑葉）	19.00	75.50	5.50	0
平　　均	24.52	68.79	6.69	0

註：1. M_0 ：無嵌紋病徵株（non-mosaic symptom plant）
　　M_1 ：輕微嵌紋病徵株（Mild mosaic symptom plant）
　　M_2 ：嚴重嵌紋病徵株（Severe mosaic symptom plant）
　　Y ：黃萎病株（Yellow dwarf plant）
　2. 供試品種種植日期為71年10月7日，調查日期為72年3月7日
　3. 調查地點為鳳山熱帶園藝試驗分所蔬菜試驗區，百分率為各品種調查200株之平均值。

三、熱水熱療對大蒜嵌紋病（GMV）不活化試驗：

熱水處理為一種最經濟最迅速之治療病毒的方法。據 Steib 等氏（1954）報告 50°C 溫湯處理2小時對甘蔗之 Ratoon stunting 有效[29]，利用 50°C 溫水處理桃枝條8分鐘可防Peach rosette，處理桃芽6～15分鐘可防 Peach x disease[29]。又利用 53°C 熱水處理唐菖蒲球根60分鐘可顯著

降低唐菖蒲之黃萎凋毒素病（BYMV）及胡瓜嵌紋毒素病（CMV）病徵[1]。如此以熱水（Hot water）處理繁殖體後種植，雖仍有病毒存在，但病徵顯著降低，似乎對病毒之不活化有效。本試驗以熱水處理大蒜種瓣以究明其利用價值或可行性。

第一次熱水熱療的結果如表3及圖1所示。處理後之種瓣燙傷度與處理溫度及時間成正比。所用蒜瓣因貯藏甚久，至一月下旬利用時已呈衰弱狀態，經熱療處理的種瓣種植後皆無成活。第二次實驗結果如表4所示。大蒜種蒜的熱水熱療處理以 48—50°C 熱水處理15分鐘爲宜，否則會影響植株生育初期之生長。又種瓣之發芽率經 48°C×45′, 50°C×15—45′, 52°C×15—30′ 等處理減低5％，經

表3. 熱水熱療對大蒜種瓣燙傷之影響

Table 3. Effect of hot water treatment on the heat injury of garlic cloves

處理代號 Treatment	溫度（°C） Temperature	時間（分） Time (min)	燙傷瓣數 Injured cloves (No)	(%)	種植後成活率 Survival plant (%)
A—1	52	15	11	55	0
A—2	52	30	12	60	0
A—3	52	45	14	70	0
A—4	52	60	16	80	0
B—1	54	15	13	65	0
B—2	54	30	14	70	0
B—3	54	45	16	80	0
B—4	54	60	17	85	0
C—1	56	15	15	75	0
C—2	56	30	16	80	0
C—3	56	45	17	85	0
C—4	56	60	19	95	0
D—1	58	15	16	80	0
D—2	58	30	17	85	0
D—3	58	45	18	90	0
D—4	58	60	20	100	0
E—1	60	15	17	85	0
E—2	60	30	17	85	0
E—3	60	45	19	95	0
E—4	60	60	20	100	0
Check	20	30	0	0	100

註：1.供試品種：黑葉硬骨種。
2.供試瓣數：每處理20個蒜瓣，21處理共計420個蒜瓣。
3.處理及種植日期：70年1月28日。

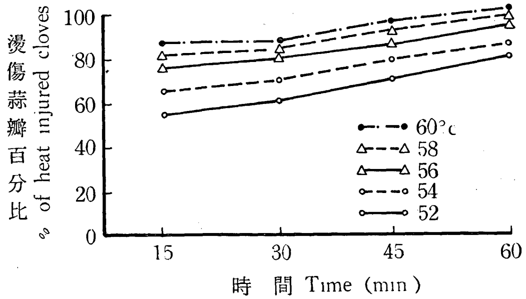

圖1. 熱水熱療對蒜瓣燙傷度之影響

Fig. 1. Effect of hot water treatment of the heat injury of garlic cloves

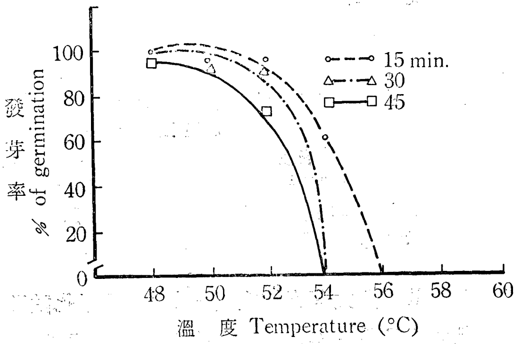

圖2. 熱水熱療對蒜瓣發芽率之影響

Fig. 2. Effect of hot water treatment on the percentage of germination of garlic cloves

表4. 熱水熱療對大蒜種瓣生長力之影響

Table 4. Effect of hot water treatment on the plant growth of garlic cloves

處理代號 Treatment	溫度 Temp. (°C)	時間 Time (min)	30天後生長度 Plant growth of 30 days					130天後生長度 plant growth of 130 days			
			發芽率 % of germination	葉數 No. of leaves	指數 Index	株高 plant height	指數 Index	葉數 No. of leaves	指數 Index	株高 plant height	指數 Index
A—1	48	15	100	3.60	79.12	17.68	72.54	10.15	103.25	51.85	101.03
A—2	48	30	100	3.45	75.82	17.09	70.12	10.47	106.51	50.76	100.85
A—3	48	45	95	3.58	78.68	16.68	68.44	9.82	99.89	45.47	90.34
B—1	50	15	95	3.63	79.78	19.94	81.82	11.22	114.14	44.94	89.29
B—2	50	30	95	2.84	62.41	11.32	46.45	8.94	90.94	39.11	77.70
B—3	50	45	95	2.79	61.31	8.65	35.49	8.94	90.94	39.35	73.18
C—1	52	15	95	3.21	70.54	11.60	55.94	9.89	100.61	40.44	80.34
C—2	52	30	90	2.61	57.36	9.11	37.38	9.19	93.48	42.75	84.93
C—3	52	45	75	3.00	65.93	8.83	36.23	9.18	93.38	42.36	84.16
D—1	54	15	60	2.94	64.61	7.99	32.78	7.88	80.16	39.25	77.98
D—2	54	30	0	0	0	0	0	0	0	0	0
D—3	54	45	0	0	0	0	0	0	0	0	0
E—1	56	15	0	0	0	0	0	0	0	0	0
E—2	56	30	0	0	0	0	0	0	0	0	0
E—3	56	45	0	0	0	0	0	0	0	0	0
F—1	58	15	0	0	0	0	0	0	0	0	0
F—2	58	30	0	0	0	0	0	0	0	0	0
F—3	58	45	0		0	0	0	0	0	0	0
Check	20	30	100	4.55	100	24.37	100	9.83	100	50.33	100

註：1.供試品種：黑葉硬骨種。

2.供試瓣數：每處理20個蒜瓣，19處理共計380個蒜瓣。

3.處理及種植日期：70年11月11日處理後種植於隔離苗床。

4.生長度調查日期：第一次於70年12月11日（種植後30天）。

第二次於71年3月21日（種植後130天）。

52°C×45′處理減少25%，54°×15′處理則減少40%，而超過54°C×30′處理則完全不發芽，故54°C×30′處理為大蒜蒜瓣熱水熱療之致死溫度與時間（圖2、3）。

蒜瓣經 54°C 熱水處理15分鐘則不僅發芽率僅達60%，而且種植後其生長度受影響很久。30天之葉數僅為對照區之65%，株高僅為 33%，130天之葉數僅為對照區之80%，株高仍僅為78%，然而對 GMV 之不活化效果維持甚久。如從後代植株（處理後14個月或後代種植後80天）取樣接種於藜指示植物上，結果如表5所示。接種後一週、二週未發現局部病斑到第三週才出現甚少量之局部病斑（單葉片平均4.5）。再從後代植株（種植後100天）之葉片取樣接種，第三週出現之局部病斑數仍極少，單葉片平均1.0可見熱療處理後之成效效果甚久，如圖4及表5所示。

一般言，熱處理溫度愈低對植物之生長度的影響愈少，如在 52°C 熱水處理15分鐘，30天之葉數為對照區之71%，株高為57%，130天之葉數為對照區之100%，株高仍為對照區之80%。如在 50°C 熱水處理15分鐘，30天之葉數為對照區之80%，株高為82%，130天之葉數為對照區之114%，株高仍為90%，且對後代植株之 GMV 不活化仍然有效，局部病斑僅為16／葉片。如在 48°C 熱水處理15分鐘，30天之葉數為對照區之80%，130天之葉數為對照區之 103%，株高101%顯示溫度愈高對抑制病毒活化之效果愈大。時間愈長則反得不利之影響，其原因有需進一步之探討。

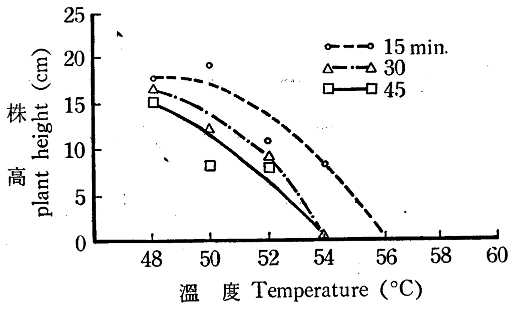

圖3. 熱水熱療對大蒜株高之影響

Fig. 3. Effect of hot water treatment on the plant height of garlic

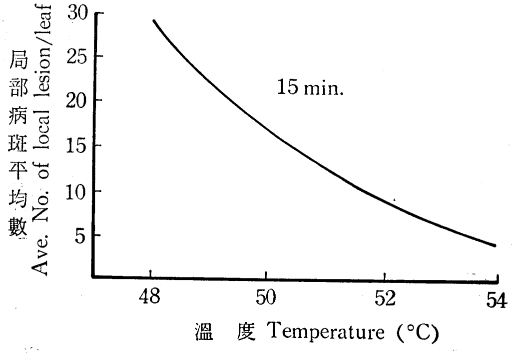

圖4. 熱水熱療對後代植株 GMV 不活化之影響

Fig. 4. Effect of hot water treatment on the inactivation of GMV in the next generation.

表5. 熱水熱療對後代植株 GMV 不活化之影響

Table 5. Effect of hot water treatment on the inactivation of GMV in the next generation.

處理溫度 Temp. (°C)	處理時間 Time(min)	感染葉/接種葉 Infected leaf/Inoculated leaf			局部病斑平均數 Ave. No. of Local lesion/leaf		
		1W	2W	3W	1W	2W	3W
48	15	0/2	1/2	1/2	0	5.0	29.0
48	45	1/2	2/2	2/2	1.5	17.5	91.5
50	15	0/2	2/2	2/2	0	14.0	16.0
50	45	0/2	2/2	2/2	0	51.5	65.0
52	45	0/2	2/2	2/2	0	13.5	62.0
54	15	0/2	0/2	2/2	0	0	4.5

註：1.供試品種：黑葉硬骨種。
2.熱水熱療及種植日期：70年11月11日種植。
70年4月19日採收蒜球。
71年11月10日再種植。
3.接種日期：72年2月2日，將接種源病毒5倍液接於2片藜葉上。
4.調查日期：接種後1、2、3週。

四、熱風熱療對大蒜嵌紋毒素病（GMV）不活化試驗：

熱風（Hot air）熱療處理對病毒不活化有效之例也很多。如胡瓜種子以 70°C 熱風處理72小時可防 CGMMV 。草莓種苗以 37°C 熱風處理7～10日可防 leaf burn 等8種 Virus，馬鈴薯塊莖以 37°C 處理30天，可使 leaf roll virus 不活化。香石竹以 36°C 熱風處理24日，可防 Carnation ring spot，桃苗以 35°C 熱風處理24日，可防 Peach yellow 等病害 [11,16] 。熱風熱療處理大蒜，並根據接種結果作綜合分析，以 B—70 及 C—60 處理之效果最大（表6），亦即如用蒜球行 40°C ，熱風熱療則以70天處理，如用蒜瓣作 40°C 風熱熱療則以60天爲最宜。

表6. 熱風熱療處理對 GMV 不活化之影響

Table 6. Fffect of hot air treatment on the inactivation of GMV in current plant

處理代號 Treatment	感染葉/接種葉 Infected leaf/Inoculateed leaf 1W	2W	3W	局部病斑平均數 Ave. No. of Local lesion/leaf 1W	2W	3W
B—40	4/5	4/5	3/5	4.2	2.4	5.0
B—50	2/5	1/5	2/5	0.8	0.8	1.6
B—60	3/5	4/5	3/5	2.8	2.6	1.8
B—70	0/5	0/5	0/5	0	0	0
C—40	2/5	2/5	4/5	0.6	0.8	3.4
C—50	1/2	2/5	3/5	0.6	0.6	1.6
C—60	0/5	0/5	0/5	0	0	0
C—70	1/5	1/5	2/5	0.6	0.8	0.4

註：1.供試品種：鳳選二號。
2.供試材料：70年2月5日於田間大蒜植株上接種 GMV。
3.B—40：蒜球（Bulb）經 40°C 熱風處理40天。
C—70：蒜瓣（Clove）經 40°C 熱風處理70天。
4.熱風處理期間：70年8月～10月。
5.種植期間：70年10—11月種植於隔離網室內木箱中。
6.接種日期：71年2月2日生育中期將每接種源病毒5倍液接於5片藜葉上，五重複，拉丁方排列設計。
7.調查日調：接種後1、2、3週。

五、生物的治療法——組織培養法與大蒜嵌紋毒素病之關係：

以生長點組織培養根除植物體內病毒之構想源自 Morel Martin [29,3] 之培養罹毒素病大理花之莖頂，獲得無病毒個體，繼之有 Morel Martin [29], Kassanis [19,20] 王盧 [2] 等人之馬鈴薯；Holmes [29] 和 Nielsen [24] 之甘藷，Phillips [26] 之香石竹等無毒化之成功。

因此利用生長點組織培養繁殖無病毒之健康苗爲避免毒素病發生之有效方法之一，我國在培養草莓與馬鈴薯之無病毒種苗方面亦已獲得良好之研究結果，而且已經進入實用階段。惟大蒜方面由莖頂生長點培養之幼苗甚爲纖細，要培育成爲普遍可種植之種瓣大小，費工費時，而且在幼苗之結球，休眠與貯藏方面需要克服許多困難才能成功。近年來作者等在鳳山熱帶園藝試驗分所隔離網室內從事組織培養苗培育工作，目前已克服許多困難，從試管培育至第五代組織培養苗 [5]。生長點培養所得之後代植株不具嵌紋病徵，但經接種到指示植物藜上，有部分植株造成局部病斑（Local Lesion）；部分植株並不造成局部病斑，初步判定爲無病毒。將組織培養後代植株葉汁液接種到指示植物藜（Chenopodium amaranticolor）葉片上之反應結果列於表7。

鳳選一號組織培養第一代苗，A 級100%，第二代苗 A 級71.42%，B 級14.29%，C 級14.29%，第三代苗 A 級50%，B 級50%，第四代苗 B 級100%，第五代苗 A 級20%，D 級20%，E 級60%。鳳選二號組織培養第一代苗 B 級100%，第二代苗 A 級70.83%，B 級4.17%，C 級8.33%，E 級16.67%，第三代苗 A 級55.56%，B 級33.33%，D 級11.11%，第四代苗 A 級20%，B 級30%，E 級50%，第五代苗 A 級33.33%，B 級33.33%，D 級16.67%，E 級16.67%。71/72年期將鳳選一號及鳳選二號兩個品種之組織培養種苗中抽樣69株檢定結果，可得 A 級50.72%，B 級21.74%，C—E級27.54%，72/73年期抽樣119株檢定結果可得 A 級52.10%，B 級21.01%，C—E級26.89%。

表7. 大蒜種蒜接種於檢定植物之反應

Table 7. Reaction of garlic clones inoculated on the indicator plants.

檢定材料 Materials tested	檢定株數 Plants tested	等級株數 No. of grade A	B	C	D	E	等級百分率 % of grade A	B	C	D	E
鳳一組培 第一代	2	2	0	0	0	0	100	0	0	0	0
第二代	7	5	1	1	0	0	71.42	14.29	14.29	0	0
第三代	2	1	1	0	0	0	50.00	50.00	0	0	0
第四代	3	0	3	0	0	0	0	100	0	0	0
第五代	5	1	0	0	1	3	20.00	0	0	20.00	60.00
鳳二組培 第一代	1	0	1	0	0	0	0	100	0	0	0
第二代	24	17	1	2	0	4	70.83	4.17	8.33	0	16.67
第三代	9	5	3	0	1	0	55.56	33.33	0	11.11	0
第四代	10	2	3	0	0	5	20.00	30.00	0	0	50.00
第五代	6	2	2	0	1	1	33.33	33.33	0	16.67	16.67
鳳一珠芽第二代	4	1	0	1	0	2	25.00	0	25.00	0	50.00
花蒜珠芽第一代	14	1	3	2	0	8	7.14	21.43	14.29	0	57.14
花蒜蒜瓣	6	0	0	1	0	5	0	0	16.67	0	83.33
鳳一梅峰	4	0	4	0	0	0	0	100	0	0	0
鳳二梅峰	3	0	0	1	2	0	0	0	33.33	66.67	0
埔里珠芽 CS—4	4	4	0	0	0	0	100	0	0	0	0
54°C×15′ 第二代	1	0	1	0	0	0	0		0	0	0
71/72 年期組織培養種蒜	69	35	15	3	3	13	50.72	21.74	4.35	4.35	18.84
72/73 年期組織培養種蒜	119	62	25	10	5	17	52.10	21.01	8.40	4.20	14.29

註：1.病毒等級A：無病毒級 Local lesion 平均數0
B：微病毒級 Local lesion 平均數0.1～5
C：輕病毒級 Local lesion 平均數5.1～15
D：中病毒級 Local lesion 平均數15.1～30
E：重病毒級 Local lesion 平均數>31

組織培養苗中，出現帶病毒之個體，很可能由於切取生長點太大所致，可能超過 200μ 以上，一般大蒜之生長點在休眠狀態下深藏在鱗瓣中，此時之生長點體積較小，未行細胞分裂，不但切取生長點困難，培養成活率低，而且有毒素病存在之可能，不宜作爲培養之材料[3] 經收水後 7—8 日長出根和葉之鱗瓣中之生長點，其周圍之葉由面包圍生長點，使生長點不易被細菌污染，且此時細胞分裂旺盛，培養成活率較高，但幼葉原體（leaf primordia）宜除去，不能隨圓錐體（dome）一同摘出培養，才能獲得根除毒素病原之個體[3,29]。通常 explant size 愈大，培養成活率愈高，但爲免除病毒，則以 excised meristen 愈小愈可能。爲了兼顧成活率及無病毒，採用中等大小爲宜，如小於 0.3mm 則不可能發根，大於 0.7mm 則仍有病毒存在之可能。至於大蒜方面據 Havranek (1972) 報告切取大蒜幼苗 400—500μ 大小之生長點培養在 MS 培養基，所得到的植株無病毒的比例爲45—87%[14]。因此大蒜組織培養苗所用之莖頂生長點 50μ. 100μ. 200μ. 300μ. 400μ 不同大小，以何種大小最適，有再試驗究明之必要。此外大蒜毒素病之傳染方法在臺灣尙無人作有系統之研究，缺乏基本文獻，如葱蚜（Fullawayella formosana），棉蚜（Aphis gossypii），葱薊馬（Thrips tabaci），銹蜱蝨（Rust mite）等害蟲之媒介功能或傳播能力亦須探明，以供本省大蒜健康種苗繁殖制度之建立與輔導工作之依據。一般蒜瓣（供試品種爲學甲花蒜）含病毒很高，屬於 E 級者達83.33%，屬於 C 級者16.67%，而 A. B 兩級均無，但其珠芽苗所含之病毒較少，A 級有7.14%，B 級21.43%，C 級14.29%，E 級僅57.14%，同時鳳選一號珠芽第二代苗 A 級25%，C 級25%，E 級

佔50%。珠芽珠球大小相當於組織培養苗第二或第三代之珠球大小，如配合熱療或藥劑處理再利用血清檢定方法或 ELISA 技術，很快地判定珠芽苗之等級則可節省很多時間與人力而且可減低大蒜健康種苗之培育成本，因此作者盼有關大學研究所或從事植物病理之研究人員加速努力研究，建立一套可實用於檢定大蒜嵌紋病毒之 ELISA 技術或制度。

結　論

1.大蒜爲臺灣重要內外銷蔬菜之一，多年來因連作及無性繁殖關係，大蒜嵌紋毒素病甚爲普遍，已對品質及產量影響鉅大，有加速培育大蒜健康種苗挽救之必要。

2.利用生長點組織，培養無病毒苗以達防治毒素病方法已有成功實例，而利用大蒜莖頂生長點組織培養雖亦有人嘗試，但尚未達實用化階段。目前作者已克服許多困難，從試管培育至組織培養苗第五代，但經生物病毒檢定結果，未能獲得 100%之無病毒種苗，以致其培育成本增加甚大。本研究就大蒜健康種苗之培育技術做一系列的病毒不活化處理實驗與探討，以便能減輕大蒜無病毒種苗之生產成本及提供一般健康種苗，能早日實用化爲目的。

3.臺灣大蒜生產地區，可發現兩種型態之毒素病病徵，一爲黃萎型（Yellow dwarf type），另一爲嵌紋型（Mosaic type），前者感染後植株顯著矮化，葉變黃而萎縮，無蒜球可收，影響產量收益甚大，所幸發病率僅在 0 —3.5%之間，佔極少比率。後者感染後植株葉片脈間，呈現濃綠與淺黃線條之嵌紋病徵，降低光合作用，影響蒜球之肥大，罹病株雖平均單球重減低20—30%，但發病率甚高，如麥寮地區硬骨黑葉品種有嵌紋病徵植株者已達98.75%，影響單位面積產量及品質鉅大。

4.大蒜栽培品種對毒素病之感病性有差異，調查23個供試品種，均無發現黃萎病株，無嵌紋病徵株平均24.52%，輕微嵌紋病徵株68.79%，嚴重嵌紋病徵株平均6.69%，罹病性較高之品種有安南蒲蒜、西螺南興硬骨大白葉與溪州硬骨黑葉，具嵌紋病徵植株達91.50—87.50%，罹病性較低之品種有莿桐硬骨大黑葉，二崙硬骨黑葉與學甲硬骨大黑葉，具嵌紋病植株約爲62%。一般言，白葉種比黑葉種之感毒素病性較大。

5.熱療處理雖無法除去病毒，但對病毒之不活化有效。大蒜蒜瓣如需要熱水熱療處理則以 48—50°C 熱水處理15分鐘爲宜，否則會影響植株生育初期之生長度（包括葉數及株高）。又48°C×45′, 50°C×15—45′, 52°C×15—30′ 等處理，使種瓣之發芽率減低 5 %， 52°C×45′ 處理使發芽率減25%，54°C×15′ 處理則發芽率減40%，而超過 54°C×30′ 處理則完全不發芽。故 54°C×30′ 處理爲大蒜蒜瓣熱水熱療之致死溫度與時間。如蒜瓣在 54°C 熱水處理15分鐘，則不僅發芽率僅爲60%，而且種植後其生長度受影響甚久。但對 GMV 之不活化效果能維持甚久，不僅影響當代植株而且一直至後代之病毒不活化。後代蒜瓣種植後80天與100天之植株抽樣接種結果，僅出現甚少量（1.0—4.5）局部病斑。

大蒜蒜球如需要熱風熱療處理，則蒜球以 40°C 熱風處理70天，蒜瓣以 40°C 熱風處理60天爲宜。

6.生長點培養所得之後代植株，不具嵌紋病，但仍有帶毒的情形發生。鳳選一號與鳳選二號兩個品種之組織培養苗72／73年期抽樣119株檢定結果獲知A級52.10% B 級20.01%，C—E級26.89%。

組織培養苗中，出現帶病毒之個體，很可能由於切取生長點太大所致，切取莖頂生長點愈大雖培養成活率愈高，但帶病毒之機會亦愈大；因此切取何種大小最適，有再作一系列試驗究明之必要。

7.一般蒜瓣含病毒很高，屬於 E 級者達83.33%，屬於 C 級者16.67%，而 A. B 兩級均無。但其珠芽苗所含之病毒較少，屬於 A 級者有7.14%，B 級者21.43%，C 級14.29%，E 級57.14%而且珠芽之珠球大小，相當於組織培養之第二代珠球大小，如配合適當之熱療或藥劑處理，再利用血清檢定方法或 ELISA 技術可很快的鑑定及培育無病毒級種苗（A 級）及低毒級種苗（B 級），可節省很多時間與人力，而且可減低大蒜健康種苗之培育成本。

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Studies on the Raising Technique of Healthy Garlic Clones in the Tropics[1]

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Summary

Garlic (Allium sativum) is one of the most important vegetable crops in Taiwan. However, the occurrences of garlic mosaic virus disease have been very prevalent due to the long term vegetative propagation, and greatly affect the yield and quality of crops. In order to rescue such serious viral harborings, the work of raising and multiplication of healthy garlic stocks should be carried out rapidly.

It has been found that the shoots of virus-infected plants are frequently devoid of viral particles or contain very low viral concentrations. Using shoot apical meristem culture become the principal techique for obtaining virus-free plants from generally infected stocks. Producing virus-free garlic clones through in vitro culture heve become one of the most effective measures to control garlic mosaic virus disease, but this techninque is slow and costly.

To date, the fifth-generation garlic stocks through meristem culture have already been raised by Fengshan Tropical Horticultural Experiment Station through overcoming lots of difficulties. The existence of GMV has been assayed with indicator plant (Chenopodium amaranticolor) and it was found that in average 52.10% of virus-free grade and 21.01% of mild symptom grade were obtained from five generations.

The virus contents were found to be higher in commercial planting cloves with 83.33% of severe sympton grade than in bulbils with 7.14% of virus-free grade and 21.43% of mild-symptom grade. Moreover, the size of bulbils are equivalent to the sizes of the second or third generation through in vitro culture. It is possible to reduce the cost of raising healthy stocks through the inactivation of virus, if combined with proper heat therapy and chemical treatments on mild-symptom or light symptom bulbils.

Although heat therapy can not eradicate the all virus particles, some effects of GMV inactivation were found. Treatment in 48-50°C hot water for 15 minutes seemed to be useful.

Treatmten in 54°C hot water for 15 minutes would reduce 40% of germination, and treatment in 54°C hot water for 30 minutes would be the critical point of lethal temperature and time.

If using 40°C hot air treatment, 70 days for seed bulbs and 60 days for seed cloves are recommended.

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柴油污染灌溉水源對水稻爲害徵狀之研究[1]

陳 美 華[2]

摘要 工業廢油污染農田，在本省逐漸成爲嚴重問題，其污染源主要來自：（1）燃料廢油，（2）潤滑油，尤其是用來洗滌與潤滑用之柴油。這些廢油隨著灌溉水源排入鄰近的農田後，首先抑制作物生長，然後進而損害作物，由於柴油屬於易揮發化合物，當其揮發後不易確定禍源。本研究目的即針對此，探討柴油污染水稻受害徵狀及組織變化，以便往後更易診斷禍源。

以臺農67號稉稻爲受試植物，分別添加0. 0.1, 0.5, 1, 2, 4cc柴油至1/5000are水稻秧苗盆栽中，每盆各植4株秧苗，每種處理三重複。處理後第二日，1, 2, 4cc柴油添加者出現急性損害徵狀，葉片萎黃且捲曲；第三日0.5cc處理亦呈葉片萎黃現象；第五日，則僅殘存 0.1cc處理之秧苗一株，其餘各柴油添加處理之秧苗皆枯死，葉片呈枯黃捲曲且佈有油漬，根部易斷腐爛且發黑。經光學顯微鏡及掃描電子顯微鏡觀察後，發現各添加柴油處理之秧苗其葉肉細胞外之泡狀細胞（Bulliform cells）皆呈破壞現象；且隨著柴油添加量增加，葉肉細胞損害程度愈嚴重，同時造成空化情形也愈嚴重。葉肉細胞中的葉綠體顆粒也遭破壞分解，使得受害部位殘留許多死細胞組織碎片。

以上結果顯示柴油確有害於秧苗，當添加0.5cc柴油於 1/5000are盆栽，即可引起明顯損害，且當添加量提高至2cc柴油時，則外觀及組織皆呈急性損害。

在石油化學工業積極發展的今日，由於石油製品取代昔日煤炭成爲主要能源，使得油污染問題日趨嚴重，其可能造成污染的來源除原油探鑽、輸送、貯存、煉製過程外，尚包括大量的工業機械用油及高濃度油污廢水或廢棄殘油處理不當等，皆能造成環境污染，污染範圍所及極廣，涵蓋水、空氣、土壤等方面，例如對水的污染，包括河川海洋由於受到浮油減低氧傳送，阻礙魚貝類，藻類之生長，或油中部分有毒成分危及水中生物生長；對空氣的污染，由於油中大量揮發性碳氫化合物之揮發，不但污染空氣產生臭味、刺激性引起人體不適，且因光化學作用造成二次污染，危害動植物生長；對土壤的污染，則改變土壤性質，妨害作物生長。因此不良影響可謂普遍且深遠。

石油因產地，種類及煉造過程不同，在組成分與性質上有極大差異，但主要成分爲碳氫化合物稱爲「烴」（hydrocarbons），餘爲非烴化合物（non-hydrocarbons）。在這些烴類中，約有0.1%屬於致癌性物質，且絕大多爲多環狀芳香族化合物（polar cyclic aromatic），其中以萘（naphthalene），2，6－二甲基萘(2，6-dimethyl-naphthalene）及 aliphatic hydrocarbons 的毒性較大[7-10]，對植物的光合作用產生抑制[11,12]，ATP含量明顯減少，使葉片萎黃或枯死且幼苗枯萎[13,14]，並且使植株的胚芽生長及種子發芽受阻，延遲或降低發芽率[15]； 水中生物也因油污染而致死率提高[16]，或使卵產生畸胚組織[17]。許多研究皆指出油毒性的强弱主要視其溶於水的部分（water-soluble fraction WSF）含量多寡而定[17,18]，因這些大半屬烴類之水溶性部分比油分子更易輸送進入生物體細胞內，危及生長與代謝。

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本省油污染農田作物案件屢有所聞，污染的問題主要來自工廠所排放燃料廢油及機械用油（包括洗滌與潤滑用之柴油）處理不當，隨污水或雨水任其流入灌溉水源溝渠，染黑溝壁，發出刺激性臭味，經排入農田後危害作物生長。因先前試驗中，發現柴油較重油對作物更具明顯毒害[1]，且柴油爲極易揮發性，事後常難確定禍源，故本研究目的即針對此柴油污染因素，進一步探討水稻作物受害徵狀及組織變化情形。

材料與方法

一、供試材料

1.供試油料：中油出品之高級柴油，成分爲 C：86%, H：13%, S：0.5%, N及O：0.5%以下[2,3]）。

2.供試植物：稉稻，臺農67號品種。

二、試驗方法

1.供試植物試驗：將生育良好之秧苗，插至1/5000are盆栽土中，土壤取自農試所農場。每盆各植四株，生長十日後，分別添加0, 0.1, 0.5, 1, 2, 4cc柴油於盆栽中，每處理各三重覆，置於溫室生長，比較水稻可能受害情形，記錄觀察受害徵狀並採受害葉片檢視組織構造。

2.植株葉片組織之構造研究

（1）石蠟切片配合光學顯微鏡（LM）觀察[4]：將正常與受害葉片，經 Craff III 固定 Johansen氏之t-butyl alcohol一系列不同濃度脫水→滲蠟→埋蠟→切片機切成10mμ石蠟帶→以蛋白甘油粘劑粘蠟帶於載玻片上→染色等處理步驟，即可在 LM下觀察葉片橫切面構造。

（2）石蠟切片配合掃描式電子顯微鏡（SEM）觀察[19]：將（1）切好之 10mμ石蠟片展粘於18×18mm蓋玻片→二甲苯（xylene）脫蠟→無水酒精洗滌→自然乾燥→以銀膠將玻片粘於鋁製標本台（specimen stub）→鍍金→在Hitachi 520 SEM下觀察葉片表面微細立體構造。

結果與討論

一、植株受害徵狀之觀察

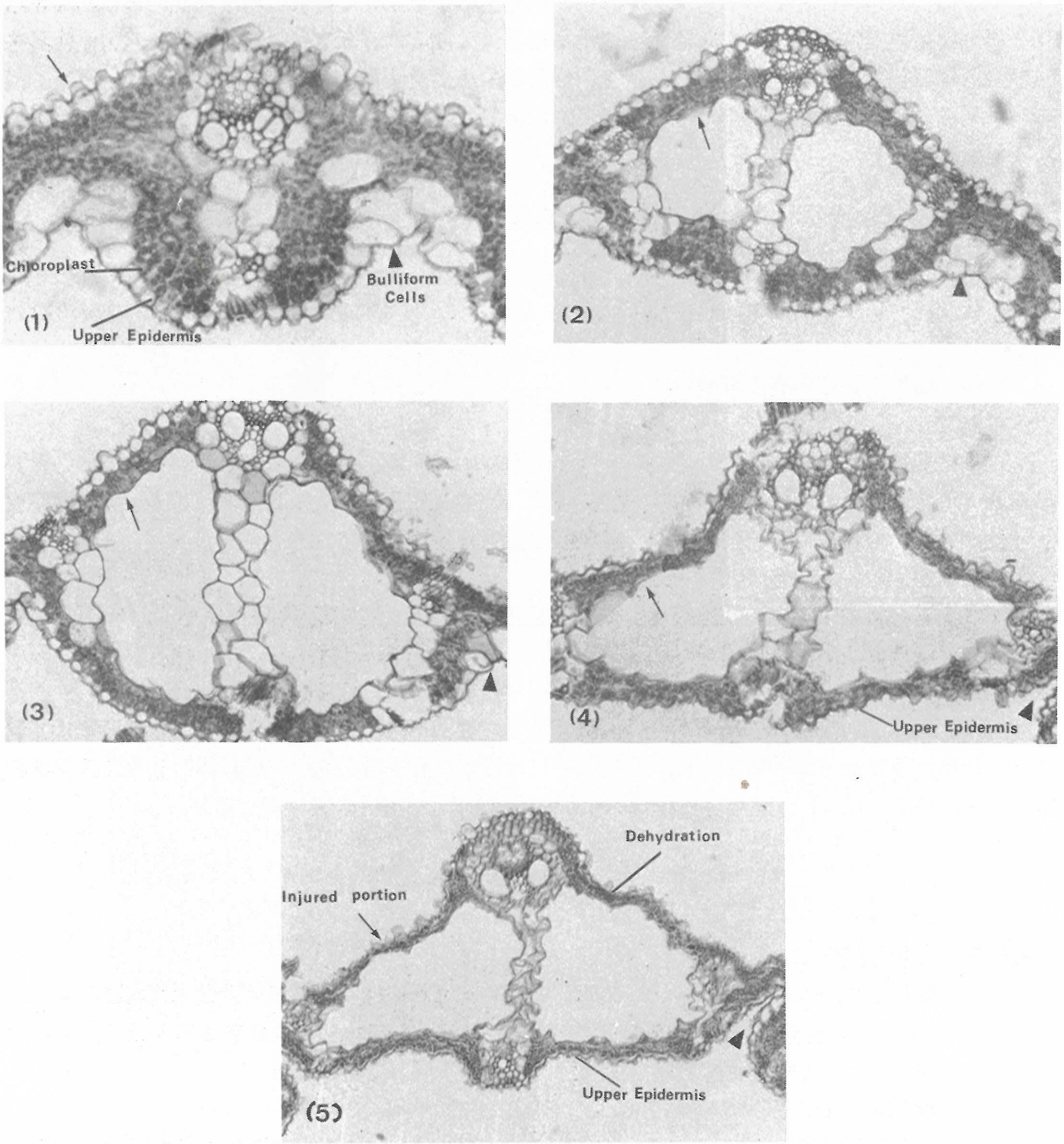
柴油添加量1, 2, 4cc者，秧苗在第二日即呈受害徵狀，葉片捲曲與萎黃，尤以 4cc處理尚佈有油污。第三日時0.5cc處理也出現枯黃現象。至第五日時，僅殘存0.1cc 處理秧苗1株而已，其餘秧苗皆受柴油毒害枯死。此外除葉片有明顯徵狀外，根部亦呈腐爛發黑易斷現象。

二、光學顯微鏡之葉片橫切面觀察

鑑於柴油處理秧苗後第三日，除 0.1cc處理未有明顯徵狀，餘皆呈枯黃現象；爲觀察同一時期之受害徵狀，僅採0.5至4cc處理之葉片做切片檢查。結果發現柴油添加量與葉肉細胞被破壞程度有正相關性，添加量越多，受害範圍越大（圖一：（1）一（5）↓所示）；尤以添加2, 4cc者表皮細胞遭破壞有極明顯變形，難辨出表皮細胞排列結構（圖一之（4）（5））。另外在 0.5cc處理發現泡狀細胞（Bulliform celk）已呈輕微破壞現象，這種情形在其他各組更是明顯可見（圖一▲所示）。而葉肉細胞被破壞後所造成的空間，也隨柴油添加量增加，破壞越嚴重且空間越大。在未添加柴油之正常葉片中，葉肉細胞內有排列整齊的葉綠體顆粒（chloroplast），但在 4cc處理則無法辨出各葉綠體顆粒（圖一之（1）（5）），這種現象可經SEM進一步加以觀察證實。

三、掃描電子顯微鏡（SEM）之葉片構造觀察

以石蠟切片製成之葉片標本，經 SEM 觀察後，明顯地發現葉肉細胞內的葉綠體顆粒，因遭柴油損害破壞分解或碎片擠壓一起（圖二之（2）至（5）中⇩所示），同時鄰近葉肉細胞外的表皮細胞，亦遭傷害失去原有結構扭曲變形。



圖一　水稻葉片橫切面

Fig.1. Cross-section of rice leaf

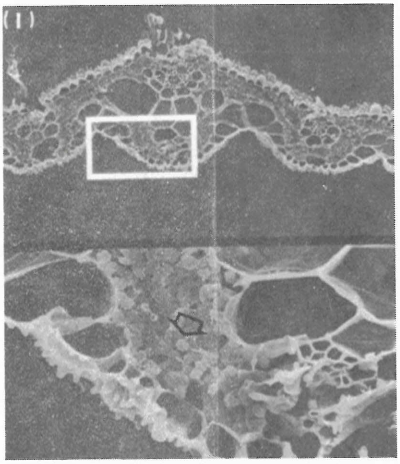
(1) 未添加柴油之對照處理（X800）
Control treatment of adding 0ml diesel oil (X800)

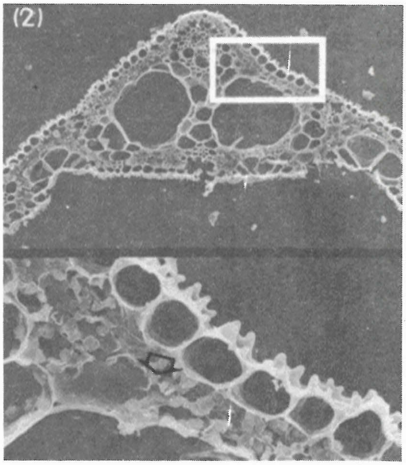
(2) 添加 0.5cc 柴油之處理（X800）
Treatment of adding 0.5ml diesel oil (X800)

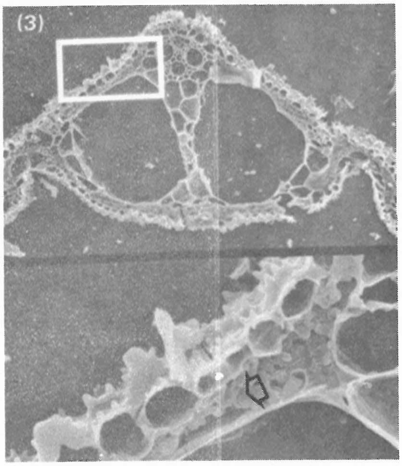
(3) 添加 1cc 柴油之處理（X800）
Treatment of adding 1ml diesel oil (X800)

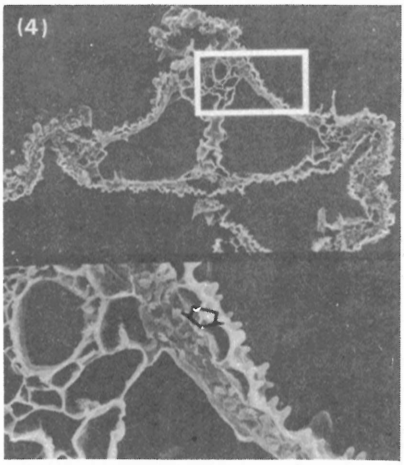
(4) 添加 2cc 柴油之處理（X800）
Treatment of adding 2ml diesel oil (X800)

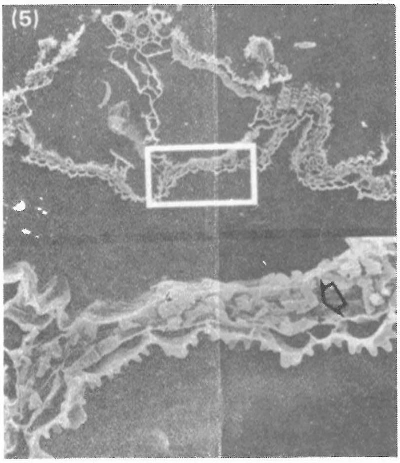
(5) 添加 4cc 柴油之處理（X600）
Treatment of adding 4ml diesel oil (X600)











圖二　掃描電子顯微鏡下水稻之葉片

Fig.2. Rice leaf under scanning electron microscope

(1) 未添加柴油之對照處理（X150）（X750）
Control treatment of adding 0ml diesel oil （X150）（X750）

(2) 添加 0.5cc 柴油之處理（X150）（X750）
Treatment of adding 0.5 ml diesel oil （X150）（X750）

(3) 添加 1cc 柴油之處理（X150）（X750）
Treatment of adding 1 ml diesel oil （X150）（X750）

(4) 添加 2cc 柴油之處理（X150）（X750）
Treatment of adding 2 ml diesel oil （X150）（X750）

(5) 添加 2cc 柴油之處理（X150）（X750）
Treatment of adding 4 ml diesel oil （X150）（X750）

觀察秧苗葉片受害徵狀皆呈捲曲或枯萎，推測因上表皮組織之泡狀細胞（bulliform cells）被破壞（圖一中▲所示），而此種細胞與葉片膨壓有關，故使葉片捲曲；另一原因，則可能因柴油有如物理性柵欄（physical barrier）阻隔或減少根部對氧氣和水分攝取，使葉片水分供應不足，泡狀細胞無法發揮功能。Amakiri等人[13]同樣認爲由於原油之物理疏水（water-repellent）特性阻礙水分與氧輸送，而使玉米發芽率降低且延遲發芽期。正因水分、氧被阻絕吸收，更不利於氣體交換，使光合作用被抑制，也妨礙ATP形成時之氧化磷酸化（oxidative phosphorylation），減少 ATP 產生，進而危及產生能量之代謝過程，使植株葉片呈萎黃，生長受到抑制而遲緩[8,11,13,14]。Watts 等[14]更指出當植株遭油污染爲害後，雖添加NH_4NO_3改善氮素營養，仍無法減輕萎黃情形。

水稻屬於單子葉植物，其葉肉綠色薄壁細胞未分化成明顯的柵狀與海綿組織，在正常葉片中可見顏色與細胞間隙一致的葉肉細胞（圖一之（1），但當遭柴油毒害時，則葉肉細胞及其中葉綠體顆粒皆破壞分解成碎片之死細胞堆擠一起，形成空化現象，且空化範圍隨柴油添加量增加而擴大（圖一、二之（2）至（5）），尤其添加 2, 4cc柴油處理組受害更嚴重，使得鄰近葉肉細胞之表皮細胞皆呈脫水現象，失去原有結構而變形。推測其原因，可能與柴油中有毒化合物有關，因這些化合物包括（1)芳香烴類：如苯（benzene）、甲苯（toluene）、二甲苯（xylene）、萘（naphthalene）、菲（phenanthrene）等（2）含氧化合物：如甲酚（cresol）、萘酚（naphthol）等（3）含氮化合物：如喹啉（quinoline）、吡啶（pyridine）等（4）含硫化合物：如噻吩（thiophene）、一硫化合物、二硫化合物、硫化氫、硫醇等[5]，幾乎皆屬揮發性化合物。當添加柴油初期，這些有毒成分揮發後，經由表皮細胞進入葉肉細胞後，破壞其中細胞，也可能殃及泡狀細胞受害，而柴油量增加更使有毒成分濃度相對提高，故使2, 4cc 處理在葉肉細胞被完全破壞後，進而破壞其鄰近之表皮細胞（圖一之（4）（5）↑所示）。劉[1,6]在其研究亦發現，添加重油10cc對秧苗生長並無明顯影響但當添加重油之盆栽緊鄰柴油添加盆栽時，則受到柴油所揮發化合物毒害，使存活率僅及85%。

另有許多研究則認爲油污染對水中生物造成毒害原因，通常係因油中水溶性部分（water-soluble fraction WSF）影響所致[7,10,11,18,20,22]，且 Millemann等人[17]在慢性毒害試驗中指出以1：8之柴油與水比例所得WSF 50cc對蝸牛卵之孵化成功率僅8%，同時卵也發生畸胚組織。因此可推測本研究中，秧苗添加柴油後的初期，雖因柴油阻礙根部之氧，水分與養分的輸送，致使葉片呈萎黃和捲曲現象，但仍有或多或少溶著 WSF 之水分，經由根部及導管輸送至葉片，進而使葉肉細胞及葉綠體顆粒被破壞，復因揮發性有毒化合物作用，讓外表皮細胞和泡狀細胞也遭到破壞與脫水，加速秧苗被傷害；使根莖相連處腐爛易斷，喪失通透性機制，導致葉片顯現油漬，根部發黑與散出刺激性臭味。Hutchinson等人[15]在其研究中指出，原油或其餾出物，有如強力接觸性除草劑，可使植物胚芽受損或死亡，尤其當植株受到傷害後，僅藉著裂孔或疤處，傷口即可滲入植物體內，而加速植株死亡。此點正與本研究終了時秧苗皆枯死的現象相似。至於葉片之維管束雖爲 WSF 輸送途徑，却未有明顯破壞，可能因它屬厚壁細胞不似葉肉薄壁細胞脆弱，故仍保有完整結構。

根據前人所做的研究及本試驗結果，可推斷柴油確會對水稻秧苗造成毒害。受害初期似以揮發性有毒化合物爲主要禍源，至末期可能因 WSF 作用，加速植株之傷害使其枯萎死亡。另外爲更深入了解全油部分及WSF之毒性對植株不良影響的比較，與受害發生途徑，宜再做進一步探討和試驗。

進行SEM觀察時，以石蠟切片取代傳統之SEM標本製備，除可改善光學顯微鏡 LM 解像力使之提高外，並可增加鏡頭焦距長度與立體空間視野，進一步易於了解SEM所得之成像。對 SEM而言，則可減少傳統製作標本的繁複手續與昂貴藥品費用，同時預先利用 LM觀察，可正確迅速找出欲觀察的變異部位，避免徒勞無功。

正因祇要添加0.5cc柴油於1/5000are盆栽中，即可引起秧苗產生輕微受害徵狀，當增加 2cc時，更使外觀及組織有明顯受害徵狀；所以有關單位應限制工廠，車廠的廢油污排放處理，禁止排入灌漑水源，以免損及農民權益及大衆健康。

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Effects of Irrigation Water Polluted with Diesel Oil on Rice[1]

M. H. Chen[2]

Summary

Farm land polluted by industrial oil is gradually become a serious problem in Taiwan. The main sources are: (1) waste fuel oil, (2) lubricants especially diesel oil used for rinsing or lubricating. These waste oils were dumped into nearby farm land and first inhibited crop growth and subsequently damage occured. Since diesel oil is a volatile compound, it is difficult to detect, once it was volatilized. The purpose of this investigation is to study the symptom of the injury caused by diesel oil waste, and makes diagnosis easier later on.

The plant material used in the study was Tainung No. 67. Rice seedlings wers transplanted into 1/5000 are pots. Six treatments were used in the study, namely 0, 0.1, 0.5, 1, 2, and 4ml of diesel oil added to the pots, each treatment with three replications. Each pot was planted with four rice seedlings. Acute injury was found in those pots treated with 1, 2, 4ml of diesel oil two days after treatment. Leaves were chlorotic and blades were curled upward. After three days, leaves treated with 0.5ml of diesel oil also showed chlorotic injury. Five days later, there was only one plant alived in those treated with 0.1ml diesel oil, the rest were chlorotic and died, blades were curled upward and were covered with oil deposit, roots were decayed, fragile and blackened. From LM and SEM examination, it was found that the magnitude of mesophyll cells injury progressed with increasing diesel oil concentration. Chloroplasts of mesophyll damaged and finally disappeared. Many dead cell tissue were found in injury area.

It is evident that diesel oil is detrimental to rice plants. Addition of 0.5ml diesel oil to 1/5000 are pot, can cause observable injury. There were tissue and morphological acute injury with addition of 2ml diesel oil.

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Interactions between Biotypes of the Brown Planthopper and Rice Varieties[1]

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Abstract : Behaviors of four biotypes of the brown planthopper on rice varieties with different resistance genes were investigated. Results showed that the behavioral and physiological responses of a biotype to rice varieties having the same resistance gene on which the biotype was developed, in general, resemble the response to susceptible varieties. The biotypes developed from the varieties with a stronger antibiotic factor to the insect showed more virulent to different varieties than those from a weaker one. Histological studies of the feeding sites in the tissues of resistant varieties revealed that no mechanical barrier to the insect's feeding involved. However, any biotype put on unsuitable host plants showed restless and changed their feeding sites frequently, and fed less from resistant varieties.

Genetic studies on the ability of biotypes to survive on resistant varieties showed that the virulence of biotype was controlled by polygenes, and dominance effects were the most important factor in determining the inability of biotype to survive on resistant varieties. A simulated study indicated that rotation and mixed planting of plants with different resistance genes will be effective in lowing the rate of development of virulent biotypes.

(Key words : Brown planthopper, Resistant variety, Biotype)

Introduction

The brown planthopper, *Nilaparvata lugens* (Stål) (Homoptera: Delphacidae) has been the most destructive insect pest of rice in Taiwan since 1960 (Tao, 1963; Ho and Liu, 1969; Chou, 1970; Cheng, 1977). For control of the pest, three to six applications of insecticides per crop season were usually practised (Yen and Chen, 1977). In order to develop the brown planthopper-resistant varieties, a research program has been initiated in Taiwan since 1969 (Cheng and Chang, 1979). So far, twelve resistant varieties have been developed and released for commercial cultivation.

Since the resistance of most newly-developed varieties are governed by major genes,

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and a plant resistance controlled by major or "vertical genes" generally is more vulnerable to a build-up of new biotypes than that of polygenic resistance (Pathak, 1970), it is important to understand the possibility of the development of new virulent biotypes of brown planthopper through the selection pressures imposed by the host, and the biological characteris-ties of the biotypes before the resistant varieties have been grown extensively in a wide area.

The majority of the planthopper populations collected from different localities in Taiwan belongs to the so-call biotype 1 (Cheng, 1975). But for the sake of comparative studies, four biotypes of brown planthopper have been developed in my laboratory through rearing the hoppers continuously on respective varieties having different resistance genes (Cheng, 1975). Thus, the original population which is unable to overcome any resistance gene is called biotype I. And the population which is able to overcome the resistance of Mudgo (with *Bph*-1), H 105 (with *bph*-2) and both Rathuheenati (with *Bph*-3) and H 105 is biotype II, III and IV, respectively.

The study is aimed to investigate the biological and genetic nature of the biotypes of the brown planthopper and to observe the effectiveness of rotation and mixed planting of varieties with different resistance genes in lowering the evolution of virulent biotypes.

Materials and Methods

1. Host preference of each biotype and its damage to rice varieties

A total of 10 rice varieties with two varieties representing each resistant gene were chosen for this study. Ten germinated seeds of each variety were sown in a row in clay plates. Seven days after seeding, the seedlings were infested separately with about 500 third-instar nymphs of the four biotypes, each with 3 replications. The number of the insects on each seedling and the damage of seedling were recorded on the 3rd and 10th days after infestation, respectively.

In order to learn whether or not differences in reactions occur between seedlings and developed plants, 60-day-old potted plants of tested varieties with one pot for each were placed together in a nylon-mesh cage. Sixty pairs of adults were released in each cage. There were 6 replications for each biotype. The number of insects on each plant and the damage of each variety were recorded onthe 6th and 30th days after infestation, respectively.

2. Survival and development of nymphs and population growth of each biotype

Thirty newly hatched nymphs of each biotype were individually reared on 10-day-old seedlings of tested vrieties. Single seedling of each variety was grown in a glass tube. After inoculation, the seedlings were renewed every other day. The molting and mortality of nymphs were recorped daily.

The population growth of each biotype on the tested varieties was measured by caging 2 pairs of newly emerged adults on 40-day old potted plants for a period of 30 days. The number of nymhs produced in each potted-plant was counted 30 days after infestation.

3. Feeding of each biotype on tested rice varieties

The feeding behavior of biotypes on varieties having different resistance genes were observed by measuring the feeding punctures, feeding site, and the amount of honeydew excretion of the insects. The feeding punctures were measured by using the method described by Naito and Makaki (1967). Feeding sites were determined by making cross-sections of the infested leaf-sheaths according to a method described by Jenson (1962), and the amount honeydew excreted by an insect was measured by following Sogawa's technique (1973).

4. Genetics of the ability of different biotypes to survive on the tested rice varieties

The biotypes maintained as inbred population in the laboratory without further purification were used as the materials in this study. Reciprocal mating was made between biotypes I and II, biotypes II and III, and biotypes I and III. Each crossing was made in a group of 10 females of one biotype and 10 males of another biotype. The mated females of reciprocal crosses, F_1 hybrids and back-crosses were allowed to oviposit on TN 1, and the hatched nymphs were used for measuing their ability to survive and feed on the differential varieties. Mudgo was used as the differential variety for the crosses between biotypes I and II, and biotypes II and III; and H 105 was used as the differential variety for the cross between I and III.

The same test procedures were used for the F_1, F_2, and backcross progeies. For testing the ability of hybrid progenies to survive on differential varieties, ten-day-old seedlings were grown in test tubes (5×18cm), each with two seedlings. Ten first-instar nymphs were released in each tube. There were 10 replications per cross. The seedlings in test tubes were renewed at 3-day intervals, and the mortality of the nymphs was recorded daily. When the nymphs became adults, they were moved out and the duration of nymphal stage was recorded. Once the nymphs which could overcome the host resistance became adults, the nymphs of the avirulent biotypes and the progenies of the crosses smaller than the fifth instar were considered as incapable of survival.

5. Effects of rotation and mixed planting of resistant varieties on the survival of each biotype a simulated study

Three varieties, Mudgo (with *Bph-1*), H 105 (with *bph-2*) and TN 1 (susceptible) were selected for this study. Each variety was planted separately in clay pots(12×10cm) with 5 seedlings per pot. Thirty days after planting, the plants were used for feeding the hoppers.

The treatment was divided into three groups: (1) the insects collected from the field were reared on a single variety separately for 12 generations. (2) The collected insects were reared on the above three varieties in rotation with one variety for 4 generations (equal to the generations propagating during a crop season), (3) The collectcd hoppers were reared on a mixture of the three varieties for 12 generations. The insects used were collected from the experimental farm of the Chiayi Agricultural Experiment Station. One hundred females were reared on TN 1 for oviposition. A group of 50 first-instar nymphs taken from the stock culture was separately released on potted plants of different varieties place randomly in wooden rearing cages (50×50×100cm). There were six plots in each cage, and four cages (replications) for each treat-

ment. When nymphs of the next generation appeared, 50 nymphs were collected from each cage and were transferred to new plants (varieties depending on the treatment). The survival rate of nymphs from each colony on TN 1, Mudgo and H 105 was determined every 2 generations as described in the second experiment.

Results

1. Host preference of each biotype and its damage to rice varieties

Seedlings and developed rice plants had significant effect in causing the difference in number of insects and damages caused by differents biotypes (Table 1). The suscep-

Table 1. Host preference and plant damage of four biotypes of brown planthopper on seedlings and adult plants of rice varieties with different resistance genes

Rice varieties		15-day-old seedling				60-day-old plant			
		No. insects/pt. on biotype							
		I	II	III	IV	I	II	III	IV
TN 1	(S)	5.9 a	6.3 a	4.3 ab	9.2 a	22.3 a	17.3 a	11.8 b	13.5 a
Tainung 67	(S)	4.2 b	4.7 bc	3.6 ab	6.8 b	11.0 bc	14.3 ab	9.0 b	14.3 a
Mudgo	(Bph-1)	1.5 c	4.2 cd	0.7 c	4.0 d	4.0 d	11.4 b	3.0 c	0.5 e
IR 26	(Bph-1)	1.2 c	4.4 c	1.3 c	4.7 cd	0.5 e	7.0 b	1.0 cd	0.5 e
H 105	(bph-2)	4.7 ab	2.9 de	4.7 a	5.8 bc	5.8 cd	2.5 c	20.5 a	5.3 bc
ASD 7	(bph-2)	3.7 b	5.0 b	4.4 ab	6.2 bc	12.5 b	3.3 c	13.3 ab	9.8 ab
Rathuheenati	(Bph-3)	0.6 c	1.8 ef	1.1 c	3.7 d	0.3 e	0.3 c	0.3 d	3.8 cd
Muthumanikan	(Bph-3)	0.5 c	1.4 f	0.4 c	3.6 d	0.3 e	0.3 c	0.3 d	7.3 b
Babawee	(bph-4)	0.8 c	1.0 f	0.3 c	3.2 d	0.2 e	0.4 c	0.3 d	0.3 e
Thirissa	(bph-4)	—	—	—	—	4.8 d	0.2 c	2.0 c	4.0 bc
		Damage gradiug1)							
TN 1	(S)	9	9	9	9	9	9	9	9
Tainung 67	(S)	9	9	9	9	9	9	9	9
Mudgo	(Bph-1)	2	9	2	3	2	9	1	0
IR 26	(Bph-1)	2	9	2	3	2	9	1	2
H 105	(bph-2)	6	7	9	9	4	4	9	6
ASD 7	(bph-2)	6	8	9	9	5	4	9	5
Rathuheenati	(Bph-3)	2	3	2	9	0	0	0	4
Muthumanikan	(Bph-3)	2	3	2	9	0	0	0	4
Babawee	(bph-4)	2	3	1	2	0	2	0	0
Thirissae	(bph-4)	—	—	—	—	0	3	2	2

1) Damage grading : 0 : no visual damage; 9 : plant killed completely.
a, b, c etc. show ranks differiog at 5% level of significance.

tible varieties TN 1 and Tainung 67 were preferred by all biotypes, and the seedlings were killed by any of them within 10 days after infestation. When test varieties were infested with biotype II, all seedlings with *Bph-1* were killed and the varieties with *bph-2* genes were also damaged severely. In contrast, when biotype III was used, varieties having *bph-2* attracted more insects resulting in a significant difference in plant damage between the varieties with *Bph-1* and *bph-2* genes. All seedlings with *bph-2* were killed within 10 days after infestation, while the damage on the seedlings with *Bph-1* was slight. Varieties with *Bph-3* and *bph-4* were not preferred by biotypes I, II and III, and the damage caused by them was negligible. Biotype IV had the ability to infest plants with *bph-2* and *Bph-3*, but was unable to infest varieties with *Bph-1* and *bph-4*. It is shown in Table 1 that the insects of biotype IV preferred varieties with *Bph-1*, and *bph-2* to those with *Bph-3*. Thereforee, it took a longer time to kill the seedlings with *Bph-3* than those with *bph-2*.

The test of 60-day-old plants for host preference of the biotypes revealed that the varieties preferred by a biotype at the seedling stage were also preferred at more mature stages. Adult insects on the preferred plants had more offsprings and caused more severe damage to the plants. However, varieties with *bph-2*, when matured, seemed more tolerant to the damage by biotypes II and IV than those at the seedling stage. Similar phenomena were also observed in varieties Rathuheenati and Muthumanikan (both with *Bph-3*) to the damage caused by biotype IV.

2. Survival and development of nymphs and population growth of each biotype

There were no significant differences in the survival of first-instar nymphs of different biotypes feeding on varieties having different resistance genes (Table 2). The survival of late-instar nymphs of different biotypes on Rathuheenati and Babawee was very low, indicating that those varieties possess a strong antibiotic factor to older nymphs. A more gradual reduction in the survival of successive instars was found on Mudgo with biotypes I, III and IV. Variety H 105 imposed a relatively low mortality rate on nymphs of all the biotypes, indicating that this variety had a weak antibiotic factor.

The brown planthopper nymphs undergo 5 nymphal instars to become adults. The

Table 2. Survival rate and duration of the nymphs of four biotypes of brown planthopper on seedling of rice varieties with different resistance genes

Rice varieties		Survival rate (%) of biotype				Nymphal period (days) of biotype			
		I	II	III	IV	I	II	III	IV
TN 1		97a	80a	87a	90a	14.3c	16.0b	15.4b	15.8c
Mudgo	(Bph-1)	30c	83a	17b	27d	16.8b	16.3b	18.5ab	18.2bc
H 105	(bph-2)	73b	70b	83a	73b	16.5b	16.8b	16.9b	17.4c
Sathuheenati	(Bph-3)	7d	3c	7c	43c	19.2a	16.7b	19.8a	19.4b
Babawee	(bph-4)	0	3c	0	10e	—	20.9a	—	26.7a

a, b, c etc. show ranks differing at 5% level of significance.

duration of each instar was generally longer on resistant varieties than on susceptible ones. The difference becomes more pronounced when the total nymphal period on resistant and susceptible varieties is considered. The duration of the nymphal period on resistant varieties was about 2 to 10 days longer than that on susceptible varieties. Nymphs suffering from a high mortality rate on a resistant variety also had a longer duration of nymphal development.

The test of population growth of different biotypes on rice varieties with different resistance genes indicated that the biotypes differed significantly in the number of progenies produced by a female on the test varieties (Table 3). In general, the number of progenies produced correlated with the longevity of females of all biotypes survived on the susceptible TN 1, while the survival of females on varieties with different resistance genes varied according to the adaptability of a biotype. Varieties Babawee(with *bph*-4) and Ptb 33 (with dominant and recessive resistant genes, unidentified) were not suitable for all the biotypes tested, and the number of progenies produced on them was the lowest. On the other hand , biotypes II, III and IV could survive on Mudgo, H 105 and Rathuheenati, respcetively. The number of progenies produced by biotype II on Mudgo, biotype III on H 105, and biotype IV on Rathuheenati was higher than those on resistant varieties with othe different resistance genes.

Table 3. Population development of biotypes of brown planthopper on rice varieties with diffenter reisstance genes

Rice varieties1)		♀♀ survival (%) of biotype				No. progenies/♀ of biotype			
		I	II	III	IV	I	II	III	IV
TN 1	(S)	90	100	90	80	241.0a	182.6a	225.0a	202.0a
Mudgo	(Bph-1)	30	90	40	50	59.0bc	184.0a	91.0b	31.0cd
H 105	(bph-2)	40	100	100	100	83.0b	103.0b	181.0a	117.0b
Rathuheenati	(Bph-3)	20	30	20	60	19.0c	7.6c	19.2c	67.6bc
Babawee	(bph-4)	0	30	50	30	3.4d	23.2c	8.8c	6.2d
Ptb 33	(?)	20	10	40	40	9.2c	10.2c	8.6c	2.4d

1) Two-pair of newly emerged adults were caged on 40-day-old plants for a period of 30days, average for 5 replications
a, b, c etc. show ranks differing at 5% level of significance.

3. Feeding of each biotype on the tested varieties

It was observed that the feeding puntures made by female adults of different biotypes differed significantly among test varieties (Table 4). The number of feeding punctures on TN 1 made by any biotype was the least. But the feeding punctures on resistant varieties made by an insect varied according to biotype. Biotypes II and III made the least feeding punctures on Mudgo (with *Bph*-1) and ASD 7 (with *bp h*-2), respectively. And biotype IV made the least feeding punctures on Rathuheenati (with *Bph*-3). Feeding punctures on Babawee (with *bph*-4) made by any of the biotypes were significantly higher than those on susceptible ones. ASD 7 was slightly resistant to

Table 4. Feeding punctures made by biotypes of brown planthopper on rice varieties with different resistance genes at 30°C

Rice varieties[1)]		No. of feeding punctures/female/24 hrs by biotype			
		I	II	III	IV
TN 1	(S)	28.7b	30.2c	28.6b	27.4b
Mudgo	(Bph-1)	53.7a	32.2bc	67.9a	56.0a
ASD 7	(bph-2)	32.6b	34.6bc	28.5b	31.1b
Rathuheenati	(Bph-3)	56.2a	65.3a	71.2a	43.2ab
Babawee	(bph-4)	51.2a	48.4ab	53.2a	56.8a

1) 15-day-old seedlings.
a, b, cetc. show ranks differing at 5% level of significance.

biotypes II and IV, it had less number of feeding punctures than highly resistant varieties. Thus, evidently hoppers on an unfavorable host plant were restless, and they

Table 5. Feeding sites observed in four biotypes of brown planthopper on resistant and susceptible varieties

Rice varieties		No. stylet sheath obd.	No. branches/ sheath	Branched sheath (%)	Place of termination	
					Phloem[1)] (%)	Vascular[2)] bundle (%)
Biotype I						
TN 1	(S)	21	1.3 a	21.3 a	59.4 b	95.4 c
Mudgo	(R)	38	2.2 c	57.9 b	23.8 a	73.7 b
ASD 7	(MR)	36	1.4 a	22.2 a	46.2 b	83.3 bc
Rathuheenati	(R)	23	1.8 b	56.5 b	19.0 a	47.8 a
Babawee	(R)	24	2.3 c	79.2 c	12.5 a	79.2 b
Biotype II						
TN 1	(S)	21	1.2 a	23.4 a	53.6 c	83.4 c
Mudgo	(S)	30	1.6 a	26.6 a	36.4 b	53.3 a
ASD 7	(MR)	34	1.4 a	32.4 ab	40.2 bc	56.3 a
Rathuheenati	(R)	34	3.9 c	85.3 d	16.1 a	67.6 ab
Babawee	(R)	37	2.0 b	52.6 c	20.1 a	70.2 bc
Biotype III						
TN 1	(S)	17	1.4 a	19.4 a	49.3 b	82.8 b
Mudgo	(R)	26	1.9 b	61.5 c	37.5 b	100.0 c
ASD 7	(S)	24	1.6 a	33.3 b	50.0 b	83.3 b
Rathuheenati	(R)	38	2.6 c	57.9 c	21.4 a	57.9 a
Babawee	(R)	20	1.5 a	40.0 b	10.0 a	90.0 bc
Biotype IV						
TN 1	(S)	24	1.2 a	23.2 a	62.1 c	92.6 c
Mudgo	(R)	34	1.8 ab	52.9 b	26.6 a	73.5 b
ASD 7	(MS)	34	1.5 a	29.4 a	44.2 b	91.2 c
Rathuheenati	(MS)	46	2.4 c	58.7 b	21.8 b	69.6 b
Babawee	(R)	32	2.4 c	81.3 c	13.1 a	50.0 a

1) Based on the termination of each branch of stylet sheath.
2) Based on each feeding puncture.

changed their feeding sites more frequently, resulted in more punctures on resistant varieties than on non-resistant varieties.

Anatomical examination of feeding sites of the hopper showed that on both resistant and susceptible varieties, the stylet sheaths of the hopper of different biotypes reached vascular bundles more than reaching non-vascular tissues (Table 5). This indicates that nomechanical barrier to feeding existed in any resistant variety. But the stylet sheath recorded in the tissues of resistant varieties tended to have a higher percentage of branching, and more branches per sheath were observed. It is possible that resistant varieties could posses some substance which was not preferable or even repellant to insect feeding.

The amount of honeyedw excreted by a sucking insect is generally correlated with the amountof food intake from the plant (Sogawa, 1973). The results of the study showed that any of the biotypes was able to intake food from plants with different resistance genes because significant amount of honeydew was excreted by an insect as compared to that fed only on water (Fig. 1). However, the amount of honeydew excreted differed significantly, depending upon the biotype and the variety. Less amount

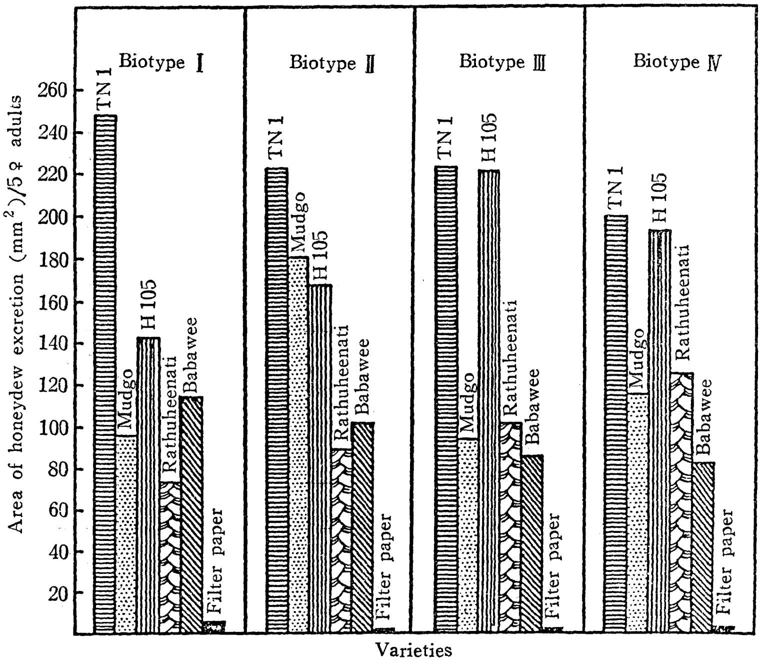

Fig. 1. Honeydew excretion of female adults of different biotypes on rice varieties with different resistance genes

of honeydew was excreted by insects feeding on resistant plants than by those on susceptible plants. It is evident that although the insects could take food from resistant varieties, they did not like to feed on them. Certain antibiotic substances produced by resistant varieties might play an important role in regulating the feeding activity and survival of hoppers.

4. Genetics of the ability of different biotypes to survive on the tested rice varieties

The mean survival rates of progenies from crosses between biotypes I and II, and biotypes II and III reared on Mudgo, and biotypes I and III on H 105 are present in Table 6. Since the differences between reciporocal crosses were minor, data for the two

Table 6. Mean survival rate of brown planthopper progenies from reciprocal crosses between biotypes Ⅰ, Ⅱ and Ⅲ, reared on Mudgo (Ⅰ×Ⅱ and Ⅱ×Ⅲ) or H 105 (Ⅰ×Ⅲ)

crosses	Generation	No. of replicates	% survival (x±s. e.)
Ⅰ×Ⅱ	P_1	10	14.0±5.4
	P_2	10	89.0±2.8
	F_1	20	18.0±3.9
	F_2	40	41.3±4.1
	BC_1	40	23.0±3.6
	BC_2	40	40.0±4.0
Ⅱ×Ⅲ	P_1	10	82.0±3.3
	P_2	10	27.0±5.7
	F_1	20	23.0±3.9
	F_2	40	65.3±3.7
	BC_1	40	47.8±3.6
	BC_2	40	52.5±4.1
Ⅰ×Ⅲ	P_1	10	42.0±2.8
	P_2	10	95.0±2.2
	F_1	20	60.5±3.0
	F_2	40	59.0±1.0
	BC_1	40	52.0±1.7
	BC_2	40	58.8±2.0

Data from reciprocal crosses were pooled since they differed only slightly.

crosses are pooled in the table. The survival rate of F_1 indicated that biotype II was recessive to biotype I and III in the ability to survive on Mudgo, as the F_1 survival rates of the I×II and II×III crosses were quite close to the parental avirulent biotypes I and III, respectively. The F_1 survival rate of I×III reared on H 105 was higher than that of avirulent biotype I, indicating that biotype I was partly dominant to biotype III in its ability to survive on H 105 . The lack of reciprocal difference suggests that the inheritance of differences between biotypes is not sex-linked.

The variations observed in F_2 and backcross populations were continuous and inappropriate for testing Mendelian segregation. The virulence of biotypes could be controlled by multiple genes. Therefore, the model of polygenic inheritance was adopted

to the data. On the basis of the mean survival rates of the parents and F_1 on resistant varieties, the degree of dominance was estimated by Mather and Jink's (1971) formulae as follows: for the cross between biotypes I and II, the mid-parental value, $m=(\bar{P}_1+\bar{P}_2)/2=51.5$; $da=\bar{P}_1(\text{or } \bar{P}_2)-m=37.5$; $ha=\bar{F}_1-m=33.5$. Then, $ha/da=0.89$. The ha/da value (less than 1) indicates that the avirulence of biotype I to Mudgo was partly dominant to the virulence of biotype II. Likewise, ha/da value for the cross between biotype I and III showed partial dominance of biotype I to biotype III; ha/da value for the cross between biotype II and III was 1.15, indicating the overdominance of biotype III over biotype II.

The data of mean survival rate obtained in F_2 and backcross were analysed by using Hayman and Mather (1955) equations to estimate gene effects with 6 parameters. The results are given in Table 7, which showed that the dominance effect (*d*) was most important in controlling the avirulence to resistant varieties in all the three

Table 7. Estimation of gene effects on percent survival of brown planthopper progenies, in reciprocal crosses between biotypes Ⅰ, and Ⅲ, by Hayman and Mather (1955) equations

crosses	m	a	d	aa	ad	dd
Ⅰ×Ⅱ and Ⅱ×Ⅰ (on Mudgo)	4.14**±0.41	2.01**±0.54	−6.66**±2.03	−3.31 ±1.97	1.75**±0.62	4.02* ±2.89
Ⅱ×Ⅲ and Ⅲ×Ⅱ (on Mudgo)	6.33**±0.37	0.48 ±0.55	−9.20**±1.92	−6.05**±1.86	− 3.23**±0.64	1.50 ±2.84
Ⅰ×Ⅲ and Ⅲ×Ⅰ (on H105)	5.90**±0.11	0.68 ±0.26	− 2.24**±0.78	−1.44* ±0.69	1.97**±0.32	5.08**±1.33

m: F_2 mean, a: additive gene effects, d: dominance effects, aa: interaction between additive effects, ad: interaction between additive and dominance efects, dd: interaction between dominance effects.

*, ** Significant at 5% and 1% levels, respectively.

crosses (minus signs for all (*d*) estimates). Simple additive effects (*a*) were insignificant in all crosses. The estimates of epistasis (*aa*, *ad*, and *dd*) indicated that the interaction between additive and dominance effects (*ad*) was significant in all crosses, while the interation between additive effects (*aa*) was significant in crosses II×III and I×III and that between dominance effects (*dd*) was significant in I×II and I×III. The nonallelic interaction between additive effects (*aa*) tended toward avirulence (minus sign), while that between dominance effects (*dd*) tended toward virulence (plus sign). The interaction between additive and dominance effects (*ad*) had different signs according to the crosses. Thus, the genic effects in crosses of the biotypes may be considered as complex.

5. Effects of rotation and mixed planting of resistant varieties on the survival of each biotype—a simulated study

When field-collected insects were reared continuously eithed on Mudgo(with *Bph*-1) or H 105 (with *bph*-2), the respective survival rate of nymphs in the first generation was 10.1 and 32.4 percent, 55.6 and 51.1 percent in the fourth generation, and 88.9

and 71.1 percent in the sixth generation (Fig. 2). By the sixth generation, the survival rate of the nymphs on the resistant variety was near to that on susceptible varieties.

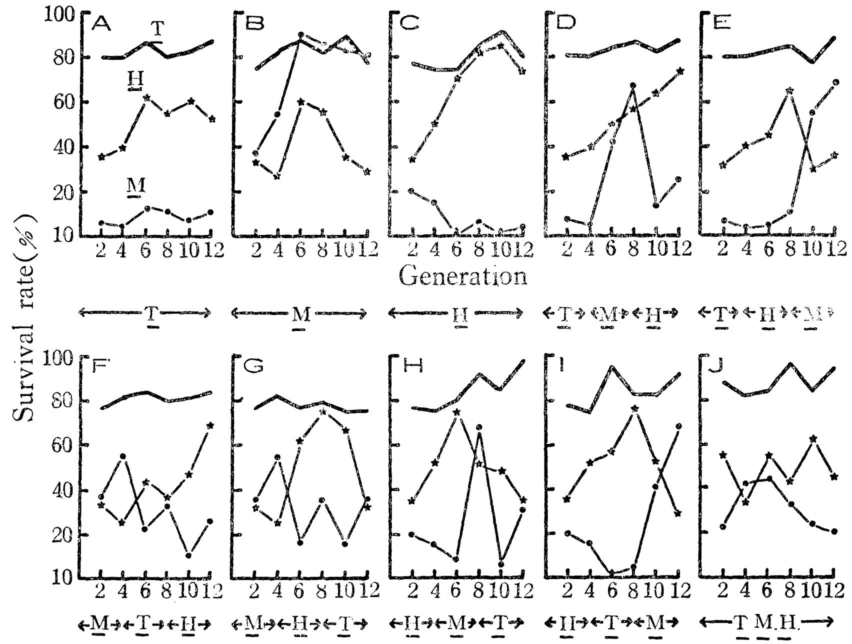

Fig 2. Survival rate of brown planthopper on resistant varieties (Mudgo, abr. as M; and H 105, abr. as H) and susceptible TN 1 (abr. as T) when they were reared on a variety continously (Fig. A–C), on varieties having different resistance genes in rotation with one variety for four generations (D–I), or on a mixture of resistant and susceptible varieties (J).

On the other hand, when the collected insects were rotatively reared on varieties having different resistance genes for every four generation on a variety, the survival rate on Mudgo and H 105 varied greatly, depending on the variety used for feeding. In general, when the hoppers were transferred from a resistant variety to another, the survival rate on the new host was low in the first and second generation, and tended to incrase in the third and fourth generation. However, the survival rate decreased again when they were transferred to another variety.

When the collected insects were reared on a mixture of varieties having different resistant genes, the survival rate of nymphs on Mudgo and H 105 varied from generation to generation, but it showed no steady increase with the lapse of generations.

The results obtained suggest that the field-collected insects were apt to shift their ability to survive on a resistant variety when they were forced to feed on the variety for 6 generations. However, when the resistant varieties with different resistance genes grown in rotation or in mixture, the survival on a particular resistant variety was evidently lower than that which was forced to feed on a particular resistant variety continuously. This indicates that rotative or mixed cultivation of resistant varieties having different resistance genes can slow down the development of new biotypes.

Discussion

Biological race have been defined as noninterbreeding sympatric populations, which differ in biology but not, or scarcely, in morphology; presumably prevented from interbreeding by preference for different food plants or other hosts (Mayr, 1976). In general, biotypes or biological races of an insect species have been referred to an insect populations possessing different physiological reactions, but no morphological distinction (Painter, 1951). It is believed by a majority of biologists that the Neo-Darwinian hypothesis of evolution involving the three steps: genetic variation, natural selection and isolation is the best theory yet advanced to explain the origin of species, as well as new biotypes (smith, 1941).

In nature, wild populations of an insect species consist of individuals genetically diverse in their ability to survive on different plant varieties, and are limited by some inherent handicap (Smith, 1941; Painter, 1951; Pathak and Saxena, 1976). When a resistant variety is planted over a large area continuously imposing a pressure of selection on the insect population, individuals that survive better on resistant varieties contribute more offsprings to following generations and finally develop a new biotype adapted to the resistant variety (Painter, 1951; Pathak and Khush, 1979).

In the present study, the biological nature of four biotypes of the brown planthopper were comparatively investigated in the laboratory. In general, the behavioral and physiological responses of a biotype to rice varieties having the same resistant gene on which the biotype was developed resemble the responses to susceptible varieties. For instance, biotype II was able to feed, develop, and reproduce on varieties with *Bph*-1 as well as on susceptible varieties. However, it is worthy to note that biotypes II and IV were more virulent to different varieties than biotypes I and III. Biotypes II and IV were not only capable of causing severe damage on varieties with *Bph*-1 and *Bph*-3, respectively, but also capable of doing moderate to severe damage on varieties with *bph*-2. Biotype III was capable of infesting varieties with *bph*-2 and susceptible varieties only. Varieties with *bph*-2 imposed a relatively low mortality on all biotypes, indicating that this group of varieties had a weak antibiotic factor, while the varieties with *Bph*-1, *Bph*-3 and *bph*-4 allowed low survival for respective biotypes feeding on them. This indicates thatthe varieties with those resistant genes possess a strong antibiotic agent to the insect.

Three biotypes of the brown planthopper were also developed in the Philippines and Japan (IRRI, 1976; Ito and Kisimoto, 1981). The reactions of biotype I and III developed in Taiwan to resistant varieties were similar to those of the Philippines and Japan. But biotype II developed in Taiwan caused more severe damage to varieties with *bph*-2 than those of the Philippines although both the Taiwanese and Phillippines biotypes were developed similarly from the resistant variety, Mudgo. A colony collected from Victoria, the Philippines where a resistant variety IR 26 (with *Bph*-1) was extensively grown, could survive on varieties with *Bph*-1 and those with *bph*-2(IRRI, 1976). The reaction of this colony to resistant varieties was more similar to those of biotype

II of Taiwan than those biotype 2 maitained at IRRI. The higher virulence of the biotype II of Taiwan than that of biotype 2 of the Philippines is probably due to the more virulence genes carried by the Taiwanese strain than by the Philippines strain.

Studies on the feeding behavior of biotypes on varieties with different resistance genes indicated that the insects put on unsuitable host plants were restless and they changed their feeding site frequently. An anatomical examination of the feeding sites indicated that no mechanical barrier was involved in the resistance. However, any biotype fed less from resistant varieties. This strongly suggested that differences in the response of biotypes to different resistance genes was likely to be due to different gustatory responses of the insect to some substance in the phloem. Observing the feeding behavior of brown planthopper on Mudgo, Sogawa (1973) suggested that the parenchymal fluid might contain some feeding inhibitory substance which play a role in determining the process of stylet insertion, and the concentration of amino acids and sucrose in vascular tissues plays an important role as phago-stimulants in determining the sustained feeding of the insects. The gustatory threshold is genetically controlled and differs according to species (Dethier, 1947). Therefore, the responses of different biotypes to different resistance genes is likely to be due to different gustatory thresholds of the biotypes to the concentration of feeding inhibitory or stimulating factors controlled by resistance genes.

The genetic stucies on the ability of biotypes I, II and III to survive on resistant varieties Mudgo and H 105 showed that virulence of the brown planthopper would not be controlled simply by major genes, as was accounted for by models of polygenic inheritance. The degree of dominance as estimated by Mather and Jinks (1971) formula indicated that the inability of biotype I to survive on Mudgo was partly dominant to the ability of biotype II, while the inability of biotype III was overdominant to the abilty of biotype II; the inability of biotype I to survive on H 105 was partly dominant over the ability of biotype III. These trends are in agreement with the results of studies at IRRI (IRRI, 1978; Sogawa, 1981). On the other hand, analysis of the data of mean survival rate of the insect progenies by Hayamn and Mather (1955) equations howed that the virulence of biotype was controlled by many genes, and supported the postulation of Claridge (1979).

Since the biotypes are differentiated by polygenic changes, field populations must be heterogeneous and variable, and the initial low virulence of a population to a resistant variety may rapidly be improved by gene recombination. This was actually observed in IR 26 (with *Bph-1*) in the Philippines, Indonesia, Solomon Islands and Vietnam, only two to three years after this variety was released (Feuer, 1976; Varca and Feuer, 1976; Mochida et al., 1977; Oka, 3977, Stapley, 1979). To cope with the evolution of new virulent biotypes, four strategies have been suggested by Khush(1979), i. e., 1) sequential release of cultivars with different resistance genes, 2) accumulation of the vertical resistance genes, 3) breeding of multiline for resistance, and 4) improvement of horizontal resistance.

The present proved that rotation and mixed planting of plants with different

resistance genes were effective in lowering the rate of evolution of virulent biotypes. This suggests that to increase genetic deversity in the field is an effective means and the breeding of multiline varieties will be most useful. Since virulent biotypes are generally recessive genetically, they may not persist in nature unless they are selected continuouslly. As discussed by Cheng (1977) and Sogawa (1982), avoidance of a mono-culture of a single variety is strongly recommended.

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褐飛蝨生物小種與抗蟲稻種之相互作用[1]

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摘 要

褐飛蝨爲本省水稻重要害蟲，栽植抗蟲品種爲一經濟而有效抑制本害蟲的方法。然而當一種抗蟲品種被連續大面積地栽培，可能引起有害生物小種之產生，而危害抗蟲品種。本研究在觀察於室內培育而成之褐飛蝨的四種生物小種在含有不同抗蟲遺傳因子稻種上的行爲反應，遺傳以及尋求可能抑制生物小種演化之有效途徑。結果顯示，由一種抗蟲品種汰選而得之生物小種在與該抗蟲品種含有相同抗蟲遺傳因子之所有品種上的行爲或生理反應，如同其存活於感蟲品種。由含有抗生性較强之抗蟲品種所汰選而得之生物小種，其危害性亦較由抗生性較弱者汰選所得之生物小種爲强。切片檢查各生物小種在各抗蟲品種之取食部位，顯示各種水稻並無明顯的機械障礙可阻止各生物小種由維管束取食。然而若將各生物小種强迫於其不適當的稻種上取食，則顯不安並經常更換取食部位，且減少其取食量，進而影響其存活與繁殖。

探討有害生物小種可存活於抗蟲品種的遺傳行爲，顯示係受數量因子所支配，顯性因子效應爲控制生物小種不能在抗蟲品種存活之主要因素。本研究亦證明使用輪植或混植含有不同抗蟲因子之稻種可有效地減緩有害生物小種之演化。

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1. 臺灣省農業試驗所 研究報告第 1233 號。本計畫承行政院農業發展委員會補助，編號爲79農建—5.1—C80（3—9），80農建—5.1—C6（3—9）及81農建—4.1—47（3—2）。

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中華農業研究 (Jour. Agric. Res. China) 34(3): 315~322 (1985)

甜菜夜蛾合成性費洛蒙之研究
I. Mitchell 配方效能檢定[1]

鄭 允 林端方 高靜華 陳先明[2] 王雪香[3] 李新傳[4]

摘要：利用 Mitchell 等在1983年所鑑定之甜菜夜蛾〔Beet armyworm, *Spodoptera exigua* (Hübner)〕合成性費洛蒙的兩種主要成份 (7)，(Z, E)-9, 12-TDDA及 (Z)-9-TDOL，所配製之性費洛蒙在本省田間也可誘得甜菜夜蛾雄性成蟲。雖然以5：1之配方也有相當的誘蟲力，但誘蟲效果仍以 Mitchell 等認定之10：1配方最好。在不同作物田中，花生、蕃茄和蘆筍田所誘得蟲數均高於大豆田。74年5月間以此合成性費洛蒙放置於73年曾遭甜菜夜蛾嚴重爲害的宜蘭青葱專業區進行誘集，所誘得蟲數已經超過中部地區花生田之誘蟲數；同時期在高雄縣岡山鎮的花生田所誘蟲數更高。配製甜菜夜蛾合成性費洛蒙時，添加抗氧化劑及油性介質均不影響誘蟲效果，且所配製出之性費洛蒙在田間可持效一個月以上。利用濕式陷阱與黏膠式乾性陷阱具相同誘蟲力，惟濕式陷阱的盆蓋與水盆間之空隙不得超過1公分，否則誘蟲效果顯著地降低。將甜菜夜蛾及斜紋夜盜蛾之合成性費洛蒙同置一陷阱時，對兩種蛾類的誘集力均不理想，兩種害蟲之合成性費洛蒙間有嚴重的相互干擾作用。

甜菜夜蛾爲雜食性昆蟲，爲害許多園藝作物如豌豆、大豆、花生、甜菜、十字花科蔬菜、茄科植物、玉米幼苗、棉花，甚至於果樹的幼苗。根據國外之報導，甜菜夜蛾喜好在莧科雜草上產卵，但因幼蟲有高度的遷移性，可以由雜草遷移至作物上而造成損害。該蟲的取食量若以大豆葉片爲標準，幼蟲期的取食量達52平方公分，約爲 *Trichoplusia ni* 之½，*Heliothis virescens* 之⅓或 *H. zea*之⅐ (3)。此害蟲之卵爲球形，直徑約0.5公厘，卵色淡青，上有縱紋。每一卵塊約有 30—100粒卵，上覆以雌蟲尾毛。每一雌蟲可產520—600粒卵，卵期3－4天。Aktins 報導幼蟲共五齡 (2)，亦有人認爲有六齡 (1)。初齡幼蟲體長1公厘，頭殼黑色，體色淡青；老熟幼蟲長25—35公厘，寬約4公厘，體型色澤如斜紋夜盜蟲，但較翠綠且變化大。幼蟲期14—21天（含1又½天前蛹期），可隨溫度而變動。蛹色淡褐，長15—20公厘，可分辨雌雄，其特徵如斜紋夜盜。化蛹喜在微濕之塊狀土壤，避開粉狀或過濕之土質，吐絲成繭，上附有土塊等雜物。化蛹處深度不超過土面下 2.5公分，易在被害田之土中採得 (5)。成蟲翅展25—30公厘·夜間羽化，當日雌蟲即可交尾，兩天後產卵，可持續產卵3—7天。由卵發育至成蟲共計需28.4天，而成蟲平均存活8天，合計36.4天。73年由本省南部豌豆田採得之甜菜夜蛾，經飼養試驗證明卵期3天，幼蟲期15天，蛹期7天，成蟲羽化後第3天開始產卵，共計由卵發育至成蟲需25天，較文獻所載稍快，可能因本省氣溫較高之故。

該蟲隨本省園藝作物面積之擴張而逐漸成爲經濟性較重要之害蟲。民國73至74年，本省各蔬菜專

1.臺灣省農業試驗所 研究報告第1234號。本研究承農發會補助，計畫編號74—農建—4.1—產植—157 (03)；及王名邦、魏品昭、蔡湯瓊、簡珠碧協助工作，僅此一併致謝。

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業區均有此害蟲大量發生及爲害之記錄，其中尤以豌豆和青葱專業區密度最高，且防治困難。由於甜菜夜蛾在豌豆之葉部爲害，若經常施藥，則豌豆採收時有殘毒問題之困擾；在青葱的問題更爲嚴重，因害蟲一旦咬破葱皮，即鑽入葱內爲害，一般施藥方法因受葱管之阻隘，無法殺死潛在葱內的幼蟲。

1972年 Brady 及 Ganyard 首先報導甜菜夜蛾性費洛蒙之主要成份爲 (Z, E)-9, 12-TDDA [4]，但此一誘劑無法在田間誘得成蟲，顯然還有其他次要成份。1981年 Tumlinson 報導另一成份爲 (Z)-9-TDOL [11]，二者之混合比爲 25ng (Z, E)-9, 12-TDDA 加 20ng (Z)-9-TDOL 時，誘效約與一隻處女蛾相當。Persoons 也在 1981 年報導甜菜夜蛾性費洛蒙的二種配方均可誘集到成蟲 [8]。1981年 Rogers 與 Underhill 以 0.1mg (Z, E)-9, 12-TDOL 及 0.01mg (Z, E)-9, 12-TDDA 混合，可誘得甜菜夜蛾 [9]。直到1983年 Mitchell 再度比較及檢討各種配方後，確認以10：1之 (Z, E)-9, 12-TDDA 及 (Z)-9-TDOL 爲最佳配方，其使用量爲0.1mg+0.01mg。此配方後來亦爲 Trumble 及 Baker (1984) 所採用 [10]，配方的正確性似乎較高。

基於甜菜夜蛾已在本省發生爲害，臺灣省農業試驗所極欲明瞭該蟲在本省各地園藝作物上發生的情形，試行以性費洛蒙建立害蟲之監視系統，並探討利用性費洛蒙與其他防治手段組成之綜合防治策略的可行性。本試驗即按 Mitchell 等研提之配方比例爲基礎，並在成品配方上加以調整，如添加抗氧化劑及油性介質，實際地探討利用此人工合成性費洛蒙之效能。

材料與方法

I.誘餌之配製

以 Mitchell 之配方爲主，所需兩主成份 cis-9-tetradecenol〔(Z)-9-TDOL, (No. T0268)〕及 cis-9-trans-12-tetradecadienyl acetate〔(Z, E)-9, 12-TDDA, (No. T0893)〕均由 Sigma 公司購得。所添加之抗氧化劑 2,6-Di-tert-butyl-4-methylphenol (BHT)、immersion oil、ether 及 n-hexane 均購自 Merck 公司。玉米油則爲源順公司產品。所配製費洛蒙誘餌係注入內徑0.6公厘，長5公分的塑膠細管中備用，共計配製下列七種配方——

a. TDDA：TDOL=10：1，不含任何添加物
b. TDDA：TDOL= 5：1，添加 BHT
c. TDDA：TDOL=10：1，添加 BHT
d. TDDA：TDOL= 5：1，添加 BHT 及玉米油
e. TDDA：TDOL=10：1，添加 BHT 及玉米油
f. TDDA：TDOL= 5：1，添加 BHT 及 immersion oil
g. TDDA：TDOL=10：1，添加 BHT 及 immersion oil

以配製100條"e"爲例，先將 0.4gBHT 溶在0.3ml 之 ether 中，俟完全溶解後加入 100$\mu\ell$ (Z, E)-9, 12-TDDA 及 10$\mu\ell$(Z)-9-TDOL，再加入少許 ether 使體積成爲 0.5ml。最後加入 0.5ml 玉米油，使總體積爲 1ml。分裝時，每條塑膠管裝 10$\mu\ell$ 混合液，兩端封口即可。平均每條誘餌含有 1mg TDDA 及 0.1mg TDOL。

II.田間試驗設計

Mitchell 等曾將甜菜夜蛾合成性費洛蒙浸入橡皮介質，置於田間之效果可以維持七星期，但未說明詳細之配方，如是否添加抗氧化劑等細節。爲確保吾人配方之有效，減少更換誘餌的次數，故仍比照斜紋夜盜蛾性誘劑之配方，添加抗氧化劑 BHT。爲明瞭各種配方之期效，不同作物田之誘集情形及不同型式陷阱的誘集效果等，分別進行下列試驗——

1.不同配方之期效檢定：測定所配製含抗氧化劑之性費洛蒙於田間狀態下，是否可持效三星期以上。試驗在農試所農場之大豆及花生田進行，所使用配方爲 a、b 和 c。

2.添加油性介質之影響：配製費洛蒙時，由於溶劑揮發迅速，常使添加之抗氧化劑再結晶，而使

分裝工作困難，故試行加入玉米油及 immersion oil 等油劑，以減緩混合液之揮發，並於田間測試其誘集效果，所用配方包括 d、e、f、g。

3.不同作物田之誘集情形觀察：本試驗除了在農試所農場的不同作物田進行以外，亦在專業栽培區測試誘集情形，測試地點爲宜蘭壯圍的青蔥專業區及高雄縣岡山鎮的花生田，所用誘餌爲b、c、e。

4.不同型式陷阱誘集效果比較：前述各試驗多以乾式的黏膠式誘蟲盒測試，但爲顧及將來推廣至田間的使用成本，宜改爲簡便的濕式陷阱，故將此二種陷阱同置田間，比較其誘集效能。

5.甜菜夜蛾性費洛蒙與斜紋夜盜蛾性費洛蒙合用時之相互干擾測定：檢定是否可將甜菜夜蛾與斜紋夜盜蛾之性費洛蒙合併應用，以節省人工及設施。

結果與討論

1.不同比例之性費洛蒙配方與添加抗氧化劑之測定結果：(Z)-9-TDOL 爲醇類，在自然環境中可氧化成醛或酸，而 (Z, E)-9, 12-TDDA 爲酯類，此二主要成份之揮發速率不盡相同，置於田間一段時間後，可能會因混合液比例改變而失效，故所配製之誘劑須經過田間持久性測定，才可以看出是否具有應用價值。表一爲甜菜夜蛾合成性費洛蒙兩主要成份以不同比例混合及添加抗氧化劑與否之誘集結果。所得顯示：大豆田及花生田經過30天的誘集，無論添加抗氧化劑與否，均不影響誘集效能。由於 (Z)-9-TDOL 可能易於氧化，除試以 Mitchell 建議之10：1 配方外，再將 (Z)-9-TDOL

表一、甜菜夜蛾合成性費洛蒙田間期效測定

Table 1. Capture of *Spodoptera exigua* males over a 30-day period in sticky trap baited with blends of pheromone components.

放置日數**	每日平均誘蟲數（隻／陷阱）					
	大豆田			花生田		
	10：1*	10：1	5：1	10：1*	10：1	5：1
第1—5日	0.33	1.13	0.40	1.40	3.00	3.80
第6—10日	0.67	0.93	0.67	1.40	2.00	1.40
第11—15日	1.10	0.27	0.47	—	3.40	1.40
第16—20日	1.80	2.29	0.93	—	3.40	7.00
第21—25日	3.20	2.73	2.67	—	9.00	2.25
第26—30日	14.40	12.07	12.00	—	20.40	4.60

*配方爲 (Z, E)-9, 12-TDDA 加 (Z)-9-TDOL ，不含抗氧化劑 BHT；後二配方均含抗氧化劑 BHT。
**試驗期間爲 5 月 4 日至6 月 2 日止。

之用量提高一倍，使之與 TDDA 之比例爲 5 ：1。此 5 ：1 誘劑亦有良好誘集效果，偶而比10：1 配方可誘得更多雄蛾，可能因 TDDA 與 TDOL 的比例在 10：1 雖好，但並非唯一最佳配方，Tumlinson 即曾以 TDDA：TDOL＝5：4 之比例，得到最佳誘集結果[11]。可能此二主要成份的比例在5 ：4 至10：1 的範圍內，均對甜菜夜蛾有相當的誘集力。此外，各陷阱鄰近環境因子及害蟲密度的影響，可能遠超過以上各配方誘集效能上的差異。在大豆田所誘蟲數普遍比在花生田爲低，可能導因於甜菜夜蛾成蟲對兩種不同作物有選擇性，但亦可能緣於二試驗田作物栽培管理方式之不同，影響到害蟲之生長與棲息，造成此蟲在田間密度上的差異，而表一中蟲數之逐漸增加則與自然密度增加有關。

2.添加油性介質之影響：以 (Z, E)-9, 12-TDDA 與 (Z)-9-TDOL 之 5：1及 10：1配方溶入玉米油及 immersion oil ，此四種配方在臺中縣烏日鄉的花生田內誘集甜菜夜蛾時，以添加玉米油的10：1配方效果最佳（表二）。進一步爲瞭解添加玉米油是否影響誘蟲效果，將僅加抗氧化劑

表二、添加不同油質對甜菜夜蛾合成性費洛蒙誘蟲效果之影響（臺中縣烏日鄉）。

Table 2. Capture of *Spodoptera exigua* males in sticky trap baited with blends of pheromone components containing different oil carrier.

放置日數*	每日平均誘蟲數（隻／陷阱）			
	5：1+BHT		10：1+BHT	
	玉米油	imm. oil.	玉米油	imm. oil.
第1—5日	2.6	4.0	17.8	3.8
第6—10日	4.6	6.4	21.8	8.0
第11—15日	8.2	9.0	8.2	5.6
第16—20日	32.8	16.0	27.2	8.6

*試驗期間爲5月12日至6月1日止。

的5：1與10：1誘劑及添加抗氧化劑與玉米油的5：1誘劑，交由桃園區及高雄區改良場，分置於73年曾經遭受甜菜夜蛾嚴重爲害的宜蘭青葱專業區及高雄縣岡山鎮的花生田。結果發現添加玉米油不影響誘集甜菜夜蛾的效果（表三）。

表三、添加玉米油之性費洛蒙在宜蘭青葱專業區及高雄縣花生田誘集甜菜夜蛾的情形。

Table 3. Capture of *Spodoptera exigua* males in welsh onion and peanut field in sticky trap baited with blends of pheromone components containing antioxidant and corn oil.

性費洛蒙配方	每日平均誘蟲數（隻）	
	宜蘭葱田*	高雄花生田**
5：1+BHT	13.7	27.9
10：1+BHT	15.8	28.9
5：1+BHT+玉米油	19.3	28.9

*三個不同地點平均誘集數，共誘集2日。

**同一地點，相隔20公尺設一陷阱，每處理3重複，共誘集5日。

3.不同作物田誘集甜菜夜蛾的情形：表四爲在農試所農場的不同作物區誘集的結果。在蘆筍、蕃茄、花生及大豆田均可誘得甜菜夜蛾雄性成蟲，一般而言，大豆田之誘蟲數較低，而在蘆筍、花生和蕃茄田所誘蟲數較多。此外，由表三的結果亦可看出，在所外的花生田及青葱田均可誘得相當數目之甜菜夜蛾，而其發生密度與作物的種類及作物之生長期有密切關聯，因此造成各地區誘蟲數之差異。

4.不同型式陷阱誘集效果之比較：由於乾式陷阱之黏膠在田間狀態下久置易失效，而降低捕蟲效能，故試以捕殺斜紋夜盜蛾所用之濕式陷阱進行誘殺。但發現原用之濕式陷阱開口太大，對甜菜夜蛾的誘殺效果甚差，必須將陷阱的開口縮小到1公分左右，並將肥皂水的液面提高，亦即減少陷阱內費洛蒙與水面的空間，誘蟲效果立刻提高，不遜於乾式陷阱（結果見表五）。因此，利用濕式陷阱誘殺

甜菜夜蛾乃屬可行，惟其設計上必須有別於斜紋夜盜蛾之陷阱。

表四、甜菜夜蛾合成性費洛蒙在不同作物田之誘蟲效果比較*

Table 4. Capture of *Spodoptera exigua* males in different crops baited with (Z, E)-9, 12-TDDA : (Z)-9-TDOL (5 : 1)

放置日數**	每日平均誘蟲數（隻／陷阱）			
	蘆筍	蕃茄	花生	大豆
第1—3日	2.33	2.67	3.33	1.00
第4—6日	1.67	1.00	2.33	1.67
第7—9日	1.33	1.33	2.00	2.33
第10—12日	6.00	3.00	6.00	3.00
第13—15日	3.00	4.00	6.00	3.33

*配方為 (Z, E)-9, 12-TDDA : (Z)-9-TDOL=5 : 1添加抗氧化劑及玉米油。

**試驗期間為5月10日至24日止。

表五、甜菜夜蛾合成性費洛蒙置於乾式及濕式兩種陷阱中，誘蟲效果之比較。

Table 5. Capture efficacy of sticky trap and water trap baited with a blend of synthetic sex pheromone.

誘集日期	甜菜夜蛾合成性費洛蒙	
	濕式陷阱	乾式陷阱
5月18日	12	8
5月19日	14	14
5月20日	8	10
5月21日	11	19
5月22日	12	7
平均誘蟲數(隻)	11.4	11.6

5.甜菜夜蛾合成性費洛蒙與斜紋夜盜蛾合成性費洛蒙之干擾作用：將甜菜夜蛾及斜紋夜盜蛾的性費洛蒙置於同一陷阱內有強烈的相互干擾作用，不但明顯地降低甜菜夜蛾誘集數，並且完全無法誘得斜紋夜盜蛾。在第五天後取出陷阱中之斜紋夜盜蛾性費洛蒙，僅留甜菜夜蛾誘劑，立即可誘得甜菜夜蛾；而在第七天取出甜菜夜蛾之性費洛蒙，獨留斜紋夜盜蛾誘劑之陷阱，則可誘到斜紋夜盜蛾（見表六）。由此判定，此二種蟲的性費洛蒙間有干擾作用，如何配製同時可誘得此二種蟲之配方，或是改良陷阱之設計，於同一陷阱內誘集兩種害蟲，均有待進一步探討。

綜合以上各項結果顯示：誘蟲數最多的配方可能為添加抗氧化劑及玉米油的10：1配方。以Mitchell 等鑑定之主成份比例，經添加抗氧化劑及玉米油，不但有利操作，且無礙於性費洛蒙之揮發及誘集效能。利用此研革後之配方置於簡便的濕式陷阱，可以作為偵測及防治本省甜菜夜蛾之有效工具。

表六、甜菜夜蛾合成性費洛蒙與斜紋夜盜蛾合成性費洛蒙互相干擾效果測定（表中數字爲誘蟲數）

Table 6. The interference of synthetic beet armyworm sex pheromone and tobacco cutworm sex pheromone in sticky trap.

誘蟲日期	BAW phero.	Litlure + BAW phero.*			Litlure
		1	2	3	
5 月 8 日	3**	0	0	1	(34)***
5 月 9 日	1	0	0	2	(3)
5 月 10 日	1	0	0	0	(17)
5 月 11 日	2	0	0	0	(13)
5 月 12 日	1	2	0	2	(14)
		取出 Litlure	取出 Litlure		
5 月 13 日	2	4	3	0	(3)
5 月 14 日	0	6	6	0	(1)
				取出BAWphero.	
5 月 15 日	0	10	10	(3)	(7)
5 月 16 日	1	5	0	(2)	(0)
5 月 17 日	1	4	7	(0)	(14)
5 月 18 日	5	13	11	1,(1)	(5)
5 月 19 日	6	10	7	(1)	(5)
5 月 20 日	8	4	4	(1)	(3)
5 月 21 日	8	17	9	(7)	(5)

*Litlure 爲斜紋夜盜蛾誘劑，成份爲 (Z, E)-9, 11-TDDA : (Z, E)-9, 12-TDDA (10 : 1) ; BAW pheromone 爲甜菜夜蛾誘劑，成份爲 (Z, E)-9, 12-TDDA : (Z)-9-TDOL (5 : 1)

**所誘得甜菜夜蛾數

*** ( ) 內數字爲誘得斜紋夜盜蛾數

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Studies on the Synthetic Sex Pheromone of Beet Armyworm, *Spodoptera exigua* (Hübner). I. Evaluation of Mitchell's Formula in Taiwan[1].

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Summary

By mixing (Z, E)-9, 12-TDDA and (Z)-9-TDOL, two major sex pheromone components of beet armyworm (BAW, *Spodoptera exigua* (Hübner)), at the ratio determined by Mitchell et al. (1983), we were able to catch the male BAW adults in Taiwan. The synthetic BAW sex pheromone is able to catch BAW in the fields of soybean, peanut, tomato and asparagus, and significant number of BAW was also caught in the welsh onion field in I-lan county, where has been infested by BAW since 1980. The synthetic BAW sex pheromone was formulated in antioxidant and oil carrier and dispensed in micro-nylon tube for field application. The addition of antioxidant and oil carrier did not reduce the efficacy of synthetic BAW sex pheromone. The formulation and dispense system we used was able to maintain the effectiveness of BAW sex pheromone for more than one month. The water trap baited with the pheromone caught as many BAW as the sticker trap except the width of entrance should not exceed 1 cm in order to maintain the high catch efficacy. The BAW sex pheromone interfered seriously with the sex pheromone of tobacco cutworm (TCW), *Spodoptera litura.* No TCW and only few BAW could be caught when sex pheromones of both species were placed in the same trap. Once, one of these two pheromones was taken out from the trap, as the interference factor was gone, the remained pheromone started to catch the insects it was originally designed for.

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麻竹銹病流行學之研究[1]

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摘要：本試驗之目的在建立痲竹銹病流行學之基本資料包括一年內之消長，病菌夏胞子發芽最適之溫度與所需的時間及存活與潛伏期，藉以了解病害發生之生態做研擬防治對策之參考。從72年1月到12月每月中旬前往雲林縣古坑鄉一選定竹園調查痲竹銹病之消長情形，結果發現一年之中均有銹病發生；若以枝條區分，靠近基部之葉片銹病最多，往上遞減；若以月份區分，則以五、六月最少，七月逐漸上升，到十月左右即達病害發生之高峰，一月枝條基部葉片開始脫落，病害逐漸減少，從一月到十二月平均葉片受害面積率爲12.8、8.4、5.3、1.9、0.2、0.6、3.0、10.3、15.8、30.4、33.9及35.8%。病菌之夏胞子在 16～28°C之間發芽均良好，但以 20°C左右最佳，夏胞子在游離水中配合適當之溫度 2 小時內即可發芽而且具有發芽能力者大約在12小時內全部發芽。在痲竹葉片上從接種夏胞子到產生夏胞子堆的時間約10～12天。夏胞子在室溫下存活大約三星期即失去發芽力，但若在病葉上大約可維持一個月，若將夏胞子或病葉保存在 4°C，經過二個月尚有50%之夏胞子可以發芽，因此掉落在竹園之乾葉片上的夏胞子不會存活太久，在落葉上也未發現有多胞子，故可能不是翌年初次感染源（primary inoculum）之主要來源，而停留在新鮮葉片上之夏胞子堆，等到次年環境條件適合時即開始產胞，才是重要之感染源，同時也是發病季節裡，造成重複感染之來源，因此清除落葉可能對病害之防治沒有太大的幫助。

痲竹（ma bamboo, *Dendrocalamus latiflorus* Munro）[5] 是本省重要的特用經濟作物，其用途甚多，痲竹筍是重要的夏季蔬菜，除鮮食外亦可加工製成筍乾或罐頭，痲竹筍是主要的外銷竹筍罐頭，每年賺取數千萬美元之外匯[1]，竹材、竹枝、竹葉等皆有許多用途，但是近來由於銹病之危害，造成早期落葉，引起有關機構及農民之重視，深恐影響植株之發育及竹筍之產量與品質，罹病之葉片其商品價值也大受影響。

痲竹在臺灣存在已經很久，可能因爲過去不是重要的經濟作物，栽培面積較少，銹病之發生也沒有目前嚴重，所以銹病未被重視，僅有眞菌學之鑑定，並未有植物病理學方面之研究，伊藤誠哉氏於1909年首先鑑定竹類銹病菌爲 *Uredo inflexa* Ito., 1928 年澤田兼吉氏[3] 認爲痲竹銹病菌爲 *Puccinia inflexa* Hor. ex Fujik.，澤田兼吉氏[4] 於1925至1941年從本省各地所採集之綠竹（*Bambusa oldhami* Munro.）、鳳凰竹（*B. floribunda* Zoll.）、痲竹（*Dendrocalamus latiflorus* Munro.）、刺竹（*Ischurochloa stenostachya* Nak.）之銹病菌均鑑定爲 *Uredo inflexa* Ito.，陳氏[2] 則認爲痲竹銹病菌是 *Dasturella divina* (Syd.) Mundk. & Khes.，而 *Uredo inflexa* 與 *Puccinia inflexa* 均爲 *D. divina* 之同種異名（synonyms）。

本研究之目的在建立痲竹銹病流行學之基本資料包括一年內之消長，病菌夏胞子發芽最適之溫度與所需之時間及存活與潛伏期，藉以了解病害發生之生態做爲研擬防治對策之參考。

1.臺灣省農業試驗所　研究報告第**1235**號。

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材料與方法

一、病害消長調查：

從72年1月到72年12月，在痲竹主要產區——雲林縣古坑鄉，選定一個竹園做調查，在該竹園選定十叢做爲固定調查點，每月十五日前往調查一次，第一次調查時，在每一叢選取生長正常具有代表性之新生枝條五個並加以標示，以後每次調查時即固定這五個枝條，調查時比照加拿大農部出版之植物病害受害面積標準圖[6]，以目測法記載每個葉片上之病斑面積。

二、溫度對夏胞子發芽之影響：

從病葉上收集新鮮之夏胞子，以含有展着劑（Tween-80, 100ppm）之蒸餾水製成胞子懸浮液(濃度爲 2×10^4 個胞子／ml)，然後將懸浮液均勻散佈在 1.5%之水洋菜（Water ager）平板上，分別放置在12，16，20，24，28，32及 36°C 之恆溫箱內，經過24小時後，以顯微鏡檢查夏胞子之發芽百分率並測量發芽管長度，每個溫度處理5個重複，每個重複計算 200個胞子，當發芽管長度爲夏胞子直徑之一倍半時即視爲發芽。

三、夏胞子發芽所需之時間：

從前項試驗選取最適合夏胞子發芽之溫度，依上述方法做發芽試驗，每隔兩小時觀察一次，觀察時先以乳酚液之棉藍溶液（lacto-phenol cotton blue：含 lactic acid 20ml；glycerol 20ml；phenol 20ml；distilled water 20ml；cotton blue 50mg）固定，然後在顯微鏡下計算發芽率，總共觀察12次，五重複，每重複計算200個夏胞子，藉以探討達到最高發芽率所需之時間。

四、潛伏期之探討、

爲避免重複感染及外界胞子之污染，試驗採用離葉法[9] 在實驗室以大型培養皿（直徑15cm）進行，首先由植株採得未經感染之新鮮葉片，將之置於培養皿內，培養皿事先經過消毒並且放置一薄層棉花，上面再加上一層濾紙（Whatman No. 1），然後以無菌水濕潤。從病葉上收集新鮮夏胞子，以前述方法製成胞子懸浮液，以噴霧法接種於上述之葉片，最後將培養皿置於實驗室操作枱上，室溫18～28°C，以觀察病勢之發展情形。

五、夏胞子存活試驗：

將病葉置於密封之塑膠袋內，另外從病葉收集之新鮮夏胞子則裝入有蓋之試管中，兩種材料各一部份保存在 4°C 之恆溫箱內，另一部份則置於實驗室內，室溫爲 18～28°C，每隔7天取出部份樣品仿前述方法做發芽試驗，於 20°C 經過12小時後觀察夏胞子發芽情形，以確定夏胞子之死活。

結果與討論

一、病害消長調查：

調查結果如表一所示，痲竹銹病一年內任何時期均有發生，但每月份有輕重之別，在同一枝條上靠近基部之葉片，因爲暴露在大自然之時間較長，所以發病都比較嚴重，而頂端之心葉則受害較輕，從一月到十二月其葉片受害面積率分別爲12.8，8.4，5.3，1.9，0.2，0.6，3.0，10.3，15.8，30.4，33.9及35.8%。四月份植物開始產生新葉，這些新生成之葉片到五月份時尚未顯現病徵，所以一年內以五月份之銹病最輕，每個枝條以6～8個葉片居多，少數枝條有9個葉片，只有基部2～3個葉片有銹病而且只是輕微發生，此時已開始出筍但量不多。六月份每個枝條有8～9個葉片，但以8片者居多，基部4～5個葉片有銹病，但不嚴重約佔1～2%，產筍量增多。七月份每個枝條約有8～10個葉片，少數枝條有10～12個葉片，銹病比六月份增加很多，基部葉片發病面積率約爲4～7%，只有頂端2～3個心葉未出現病徵，極少數之枝條上的葉片已全部被感染。八月份由於在七月下旬韋恩颱風侵襲，吹落許多葉片，因此每個枝條約有5～6個葉片，若未被吹落者亦有9～12個葉片，銹病比七月份更加嚴重約爲9～20%，並已進展到頂端心葉。九月份因爲無颱風來襲，加上氣溫高雨水多

，產生許多新葉片，每個枝條大都有10個葉片以上，亦有14～16個葉片者，靠近基部之葉片銹病已有25～35%左右，因爲早晚氣溫已較涼爽，濕度又大，很適合於銹病之發生與傳染。十月份新葉生長已趨緩慢，每個枝條約有 7～12個葉片，但亦有15片者，靠近基部葉片銹病病斑面積率達已45～50%，達銹病發生之最高峯，唯心葉病斑面積率仍在 1 %左右。十一月份植株生長近於停止，本月五日停止收購竹筍，農民自行加工處理，開始砍除老株留新株，所砍除之老株若有葉片大者農民大都採收晒乾後出售做爲包粽子之用，本月份每個枝條有 8～12個葉片，但亦有14～15片者，靠近基部銹病約爲50%，心葉約爲 2～3 %。十二月份新葉生長近於停止，心葉之銹病亦達 8～10%，另外新株之葉片已受感染，一個枝條上有四分之三以上之葉片銹病超過30%。一月份銹病看來比十二月份輕，這是因爲基部受感染之葉片脫落之故，故每個枝條只剩 7～9 個葉片，基部葉片之銹病約爲25%，心葉約爲 2～5 %。二月份又有一部份葉片脫落，每個枝條只剩 6～8 個葉片，基部銹病約在10～20%，心葉爲 2～4 %，越冬之病斑已有少量新鮮夏胞子產生，準備感染新生葉片。三月份之情形與二月份相似，但有些枝條有一個新葉產生而且因爲基部葉片脫落，所以銹病顯得少些。四月份新葉之生長更多，而且均未出現病徵，所以銹病又形減少。

麻竹銹病大約從七月開始大量發生，所以要施藥防治的話，此時爲最佳之時機，太早施藥則造成浪費，太晚施藥則不易收到防治的效果。因爲銹病造成落葉之時間與植株之休眠期相同，所以有些農民認爲落葉是自然的生理現象，至於銹病所造成之落葉是否會影響當年或翌年之出筍量，如果有影響，究竟有多大，這些都缺乏實驗之結果來證明，如果用人工以化學藥劑來防治，由於多年生植株高大施藥不易恐難收效，又因竹筍豐產時價錢便宜，是否合乎經濟防治之原則亦有待商榷，但是受銹病感染後將降低葉片做爲包粽子用途之商品價值是無可懷疑的，因此局部施藥以獲得優良品質之粽葉或許有其經濟價值。

表一：麻竹銹病1983年消長調查結果（雲林、古坑）

Table 1：The incidence of ma bamboo rust at Kukeng, Yuinlin in 1983

葉序** leat position	月份 month											
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	25%*	15	10	5	1	2	5	20	35	50	50	50
2	20	15	10	5	1	1	5	20	30	48	50	50
3	20	10	8	4	0	1	5	15	30	47	50	50
4	15	10	5	1	0	1	4	15	20	45	45	50
5	10	5	3	0	0	0	4	10	15	40	45	45
6	5	3	1	0	0	0	3	10	15	35	40	45
7	5	1	0	0	0	0	3	5	10	30	35	40
8	2			0	0	0	1	5	10	20	35	30
9						0	0	2	5	20	30	30
10							0	1	3	15	20	25
11									1	10	5	10
12									1	5	2	5
平均(%) Average	12.8	8.4	5.3	1.9	0.2	0.6	3.0	10.3	15.8	30.4	33.9	35.8

*：葉片受害面積百分率（十叢五十個枝條之平均值）
Percentage of leaf area covered with uredia (average of 50 branchlets)

**：從枝條基部算起
from stem-end to the tip-end.

二、溫度對夏胞子發芽之影響：

表二爲麻竹銹病菌夏胞子在各種溫度下發芽及發芽管生長的情形，結果顯示麻竹銹病菌之夏胞子在 16～28°C 之範圍內發芽良好，但以 20°C 最好，其發芽管生長之適合溫度與發芽之適合溫度相同，由於麻竹銹病發生嚴重之季節裡，早晚濕度較大時之氣溫正好與夏胞子發芽之溫度相配合，所以造成重複感染與大量危害，冬季若有寒流來襲，早晚氣溫會降到 10°C 以下，因爲夏胞子在此溫度條件下不易發生侵入，所以銹病之發生較少。

表二：溫度對麻竹銹病菌夏胞子發芽之影響*

Table 2: Effect of temperature on the uredospore germination of ma bamboo rust

	溫 度 Temperature (°C)						
	12	16	20	24	28	32	36
發芽百分率 (%) Percent germination	7	74	84	76	68	4	0
發芽管長度 (μ) Length of germtube	120	483	587	519	272	7	—

*在1.5%水洋菜平板經過24小時後之觀察結果，每處理 5 重覆，每重複觀察200個夏胞子之平均值。
Experiments were conducted on 1.5% water agar plate for 24 hr. with 5 replicates. Two hundred spores were counted for each replicate.

三、夏胞子發芽所需時間：

表三結果顯示，夏胞子在最適合於發芽之溫度下，2 小時即開始發芽，而在12小時左右即達最高之發芽率約爲86%，即使 4 小時也有55%，因爲夏胞子堆所釋放的夏胞子數量很多，因此即使只有二分之一的夏胞子獲得良好之發芽與侵入也就足以造成相當程度之危害。

表三：不同時間麻竹銹病菌夏胞子之發芽百分率*

Table 3: Uredospore germination of ma bamboo rust at deiffernt times at 20°C

	時 間 Time (小時 hr.)											
	2	4	6	8	10	12	14	16	18	20	22	24
發芽百分率 (%) Percent germination	27	55	75	79	82	83	83	84	87	86	87	87

* 在1.5%水洋菜平板測試結果，每處理 5 重複，每重複觀察200夏胞子，試驗在攝氏 20°C 之恒溫箱進行。
Experiments were conducted on 1.5% watre agar plates and incubated at 20°C with 5 replicates. Two hundred spores were counted for each replicate.

四、潛伏期之探討：

本試驗初步用離葉法在培養皿內進行接種試驗之結果顯示在室溫 (18～28°C) 下，經過 5 ～ 6 天即可看見退綠色隆起之病斑，10～12天夏胞子堆即發育完全並產生夏胞子。

五、夏胞子存活試驗：

表四結果顯示若將夏胞子保存在室溫下，其存活力不會超過三星期，因爲二星期後發芽率即降到30%以下，三星期後幾乎完全失去發芽能力，但在病葉上之夏胞子保存在室溫時經過四星期後，還有大約40%之夏胞子可以發芽，這是因爲早期葉片仍未死亡，足可維持病菌之生存到一星期左右，而後發芽率才開始下降，若將病葉或夏胞子在 4°C 之冰箱冷藏保存，則在十週以後，夏胞子還有50%左右的發芽率，以上之結果和一般其他之銹病菌相似，夏胞子在室溫條件下存活約只有三星期，而冷藏

可以保存其活力到數月之久[7,8]，因此掉落在竹園之乾葉片上的夏胞子不會存活太久，可能不是第二年重要的初次感染源（primary inoculum）之來源，而停留在新鮮葉片上之夏胞子堆，等到翌年環境條件適合時即開始產胞，才是重要之感染源，同時也是發病季節裡，造成重複感染之來源，因此淸除落葉可能對病害之防治沒有太大的幫助。

表四：痲竹銹病菌夏胞子存活試驗*

Table 4: Survival tests of uredospores of ma bamboo

保存條件 Storage condition	保存時間（週） Storage time in week										
	0	1	2	3	4	5	6	7	8	9	10
室溫 Room temperature, 18～28°C											
試管 in test tube	84%	75	29	1	0						
病葉 in diseased leaves	84	83	20	13	38	1	0				
冰箱 Refrigerator, 4°C											
試管 in test tube	84	71	69	70	69	70	67	67	49	43	40
病葉 in diseased leaves	84	83	85	76	73	69	66	67	55	53	48

*夏胞子取出後在1.5%水洋菜平板做發芽試驗，經 20°C，12小時，每處理5重複，每重複計算200個夏胞子，求其平均發芽率。

Experiments were conducted on 1.5% water agar plates with 5 replicates. The plates were incubated in a incubator at 20°C for 12 hrs. Two hundred spores were counted for each replicate.

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The Epidemiology of Ma Bamboo Rust[1]

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Summary

Due to the intensive and extensive culture of ma bamboo (*Dendrocalamus latiflorus* Munro) in the recent decades, rust of ma bamboo has become a disease of economic importance in Taiwan. Informations of this disease in the literatures were mycological studies such as host range, identification and morphological description of the causal organism without any pathological or epidemiological research. We report the incidence of ma bamboo rust in a year, the effect of temperature and time on the germination, the survival and the growth of germ tube of uredospores, and the incubation period of ma bamboo rust on the detached leaves. Observations were made in a ma bamboo field at Kukeng, Yuinlin County where ma bamboo is a major crop. Five labeled branchlets each of the ten randomly selected bushes were observed leaf by leaf once a month in the middle of every month in 1983. A standard key of cereal rust was used to assess, by naked eyes, the percentage of ma bamboo leaves covered with rust lesions. Mean percentage of the 50 branchlets were recorded with 12.8, 8.4, 5.3, 1.9, 0.2, 0.6, 3.0, 10.3, 15.8, 30.4, 33.9, and 35.8% of rust lesions from January through December, respectively, and the severity of the leaves on a branchlet decreased gradually from stem-end to the tip-end. Fresh uredospores from infected leaves were used to prepare suspension (ca. 2×10^4 spores/ml) for inoculation and germination tests. Germinations were conducted on 1.5% water agar plates at various temperature regimes and times. The optimal temperatures for germination and growth of germ tube were observed between 16 and 28°C with a maximum at 20°C. Uredospores germinated within 2 hours at 20°C and reached to the highest percentage of germination in about 12 hours. The incubation period of the disease on the detached leaves were recorded 10 to 12 days in petri plates at room temperatures (18-28°C). Uredospores lost their viability drastically at room temperatures. However, if they were stored at 4°C, about 50% of the uredospores were still able to germinate after 8 to 10 weeks. Therefore, we consider the uredospores in the diseased leaves falling on the ground are not important source of inoculum for the epidemics of the following year. Collecting and burning of the diseased leaves on the ground may give little help for the control of ma bamboo rust in the field. No teliospore formation was observed during the course of this study.

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藥劑防治香菇木屑包發生雜菌*Trichoderma* spp.效果之探討[1]

廖 英 明[2]

摘要：本研究係探討供試五種藥劑在洋菜培養基中及加於木屑培養基後對發生雜菌*Trichoderma* spp. 之防治效果。本試驗證實某些藥劑對於香菇栽培時雜菌之發生具有抑制作用，而在初步篩選時係將藥劑加於 PDA 平板來測定其藥效，並與未加藥劑比較。本研究可歸納如下：

（1）在培養基試驗時，五種藥劑中只有Penmush（＝Y101）及Tecto-60在50ppm濃度時對*Trichoderma* spp. 菌絲之生長有抑制作用，而若濃度提高到400ppm則五種藥劑均有抑制效果。

（2）除了 Tecto-45 外，所有藥劑在2,000ppm時對香菇菌絲生長無明顯影響。

（3）在木屑包栽培試驗時，將*Trichoderma* spp. 胞子接種於木屑包中，且以 Penmush（＝Y101）或 Tecto-60 混合於木屑包時，則二星期後有98%之防治效果，繼續培養到五星期後則防治效果分別為97%及90%。

（4）Penmush（＝Y101）及 Tecto-60最適合之使用量為每包加入 0.2g（200ppm），這種藥劑量對香菇菌絲生長及菇體形成，以及產量都無影響。

（5）由以上結果可知 Penmush（＝Y101）及Tecto-60在室內及木屑包之試驗時均具有相同之良好抑制雜菌之效果。

香菇是本省近年來栽培的新興菇類，栽培面積及數量正在擴大中，且栽培地區有從山地往平地擴展的趨勢[20,21]。在本省大規模木屑包製造生產時，栽培基質之木屑其因常年堆積而成為雜菌繁衍的來源，又全年均有木耳、鮑魚菇、香菇、金針菇或靈芝之栽培，在其栽培過程中亦是雜菌傳播之媒介。由於木屑培養基之營養成份高，雜菌胞子極易發芽，因此要減少培養基質中之雜菌為菇類木屑包栽培時之首要工作。不論是段木栽培或是木屑包栽培，在菌絲培養時期常受高溫多濕的影響，導致雜菌嚴重發生，一般常見的雜菌有白黴菌（*Cladobotryum veriosperum*），綠黴菌（*Trichoderma* spp.），青黴菌（*Penicillium* spp.），黃麴菌（*Aspergillus* spp.），紅麴包黴菌（*Neurospora* spp.）及放射菌（*Actinomyces* spp.）等[8]，而其中又以綠黴菌的為害最大。在日本，以木屑培養基來栽培菇類時，常將藥劑混合於金針菇，蠔菇及珍珠菇培養基中，再經殺菌而可預防雜菌之發生，且有增加單位產量之效果[8]。綠黴菌中之*Trichoderma viride*，其菌絲生有瓶狀枝孢子梗且孢子有粗糙突起及 *T. harzianum*，其孢子為平滑球形，是本省菇類栽培上較重要之二種有害菌，而兩者均可產生抗生物質，使香菇菌絲無法生長[5,6,7,9,14,19]。Komatsu[12] 由日本香菇段木栽培場所分離之 *Tric-*

1.臺灣省農業試驗所研究報告第1236號。本文為農委會補助計畫（73—農建—2.1產—101（2）—戌）之部份結果。試驗進行中承廖莉莉小姐協助，文承葉忠川博士斧正，特此誌謝。

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hoderma spp. 依其菌落外觀及來源，可區分爲綠色 Sc 型（Schweinitzii formed），白色 L 型（Lactea formed），及橄欖色S型（Soil formed）。各型之發生適期不同，如 Sc型在低溫下仍可生長良好，且大都發生在乾燥時期，L型最適合於多濕狀況下，而在 30°C之高溫下則以Sc型及S型爲害最大，在10～20°C下則以L 型爲害較大[13]。但在落葉及段木上以*T. lignorum*最爲常見[15]。*T. viride* 在含水量爲18.7～28.6%時仍可生存，30%以上則所有 *Trichoderma* spp. 均可生存[18]。Arita[2] 調查日本之香菇栽培場發現有83%的栽培場其段木均感染 *T. viride*，而且僅見其分生孢子世代而不具有性世代（*Hypocrea* sp.）的佔65%，由此可見若有良好的生存基質，Trichoderma 屬菌大都以孢子型態來生存，而*T. viride*亦被發現多發生於通風不良場所。

當綠黴菌與香菇菌絲接觸時會產生拮抗線，而迫使後者停止生長[22]，且幾乎所有的 Trichoderma 屬菌均有此現象，而其培養過濾液也有相同作用。將受抑制的香菇菌絲在 25°C下培養仍無法回復生長[16,17]。香菇菌絲和 *T. harzianum* 接觸時會產生褐變，且香菇菌絲會被殺死，此乃由於粗酵素及中性抗菌物質之作用而抑制了香菇菌絲的呼吸，最後使香菇菌絲死亡[10]。培養基中若含有葡萄糖（glucose）則可刺激香菇菌絲產生對*T. viride*之抗性，但若含木糖（Xylose）或蔗糖(Sucrose)則會加速菌絲之溶解，尤其在氮素增加時更爲明顯[11,25]。在早期香菇栽培研究中，對雜菌之防治極爲重視，如對段木栽培場之消毒，如以蒸氣來殺滅殘存於土壤中之雜菌效果極爲良好[24]。而在木屑培養基中若加入有機水銀及五氯酚鈉（Na-PCP），用量爲0.001%及0.1%時即有抑制雜菌發生的效果[1]，但這些藥劑現已因殘毒問題而被禁用。後來Fukai[3] 發現Benomyl用量在 0.25ppm時即對 *T. viride*具有抑制作用，且又在木屑培養基中加入10ppm即可防止*T. viride*之生長，此種加入木屑培養基之方式主要係應用在珍珠菇(*Pholiota nameko*) 之栽培上。而在香菇方面，若濃度在500ppm以上則會影響香菇菌絲生長。Ogawa[23] 亦曾將 Benomyl 應用於其他菇類之雜菌防治，如用在蠔菇（*Pleurotus osreatus*）時爲 100～500ppm，珍珠菇爲 100～500ppm，金針菇（*Flammulina velutipes*) 爲40～60ppm時，則可抑制*T. viride*，且對食用菇之菌絲生長無影響。

在藥劑使用上，一直是病害防治之有效方法，但其安全性爲重要考慮因素之一，如毒性低之化學藥劑之開發，而食品添加劑均屬於毒性低之化學物質，如能用在殺菌方面較爲有利。TBZ (Thiabendazole) 系統藥劑即爲食品添加劑之一種，主要用來抑制*T. viride*及 *Penicillium citrinum*[4]，因此選擇 TBZ系統藥劑來作爲香菇木屑包發生雜菌之防治藥劑，其毒性低比較安全。徐氏[8] 試驗後發現TBZ系統之Penmush（=Y101）可加入栽培材料中，且可耐高溫，使用量爲5,000～8,000倍，若混合於金針菇之栽培材料可使雜菌之感染率降爲 1 %以下，但會使金針菇之出菇延遲 1 ～ 2 天，而對產量有提高趨勢。在香菇方面，本省尚無此項資料，尤其在本省香菇栽培所使用之木屑包及菌種製作時雜菌之防除更爲重要。因此本試驗以木屑包栽培基之主要雜菌 *T. viride*及 *T. harzianum*爲對象，來探討不同來源之TBZ系統藥劑在本省香菇木屑包雜菌發生預防之功效及其可行性。

材料及方法

一、供試藥劑：選用原廠生產之 TBZ 系統藥劑黴敵(Mertect-340)，Penmush(=Y101)，Tecto-45及Tecto-60與Benomyl等五種藥劑試驗，且各種藥劑在試驗時以 50至 5,000ppm之濃度進行試驗，另在木屑包防治試驗時以本省自行配製或分裝之藥劑加入於試驗處理供作比較用。各藥劑之成份如下，而來源及用量則如表 1 所示。

Mertect-340	主要成分	2-(4-Thiazolyl)－benzimidazole 40% w/w
Penmush（=Y101）	主要成分	2-(4-Thiazolyl)－benzimidazole 60% w/w
Tecto-45	主要成分	2-(4-Thiazolyl)－benzimidazole 45% w/w
Tecto-60	主要成分	2-(4-Thiazolyl)－benzimidazole 60% w/w
Benomyl	主要成分	Methyl-1－(butylcarbamoyl)－2-benzimidazole－

carbamate 50% w/w

二、供試香菇品系：本試驗以目前本省栽培數量較多之森 465號品系爲試驗材料。其菌絲體係由本省木屑包栽培所得之子實體經組織分離而得。

三、供試雜菌：由本省三處香菇栽培場分離所得之*Trichoderma viride*及*Trichoderma harzianum*將其菌絲培養於 28°C，一星期後取其孢子懸浮液，並調整濃度爲 7500個孢子/ml，混合後作爲接種源。

表1. 供試藥劑及處理別

Table 1. Treatments of fungicides on sawdust for the control of weedmolds in shiitake cultivation

處理 Treatment	藥劑 Fungicide	來源 Source	用量（克／包） Dosage (g/per bag)
1	Mertect—340[a]	臺製	0.3
2	Mertect—340[a]	臺製	0.2
3	Mertect—340[a]	分裝	0.3
4	Mertect—340[a]	分裝	0.2
5	Penmush (=Y101)	日本	0.2
6	Penmush (=Y101)	日本	0.12
7	Tecto-60[a]	Merk sharp & Dohme MSD (Asia)	0.2
8	Mertect—340[a]	Merk sharp & Dohme MSD (Asia)	0.3
9	Mertect—340[a]	Merk sharp & Dohme MSD (Asia)	0.2
10	CK	—	—
11	Penmush (=Y101)[a]	臺製	0.2
22	Penmush (=Y101)[a]	臺製	0.12
13	Benomyl[b]	Dubbin S. P. A.	0.2

a. 藥劑由美商臺灣新美公司提供
The fungicides were provided by U. S. Summit Crop Taiwan branch.
b. 藥劑係採購於市面。
The fungicide was purchased at the pesticide store.

四、室內之篩選，將原廠生產之各種藥劑混合於馬鈴薯洋菜培養基（potato 200g, dextrose 20g, agar 20g, D. W. 1 litre），調整其濃度爲 50，100，200，500，1000，2000，4000及 5,000 ppm，並以打孔器打成直徑5mm大小之孔，將同一大小之 *Trichoderma* spp. ，菌絲塊移入平板中央（內徑八公分），後置於28°C培養，14天後量取菌落直徑，並選取優良藥劑。

五、各種藥劑對香菇菌絲生長之影響：如前項方法，將原廠生產之藥劑混合於馬鈴薯洋菜培養基中，調配成不同濃度，後將直徑5mm之香菇菌絲塊（森465）移入，二星期後比較加藥劑與未加藥劑之菌落直徑。

六、木屑包藥劑防治試驗：由前兩項方法中，選取優良藥劑Mertect-340, Penmush (=Y101), Tecto-60及Benomyl作爲試驗藥劑，另加入臺灣自行配製及分裝之 Mertect-340 及 Penmush作爲比較，如處理1，2，3，4，11及12，各處理之劑量如表1所示。每處理40包木屑包，四重複，並區分爲不接種雜菌（試驗A）及接種雜菌（試驗B）兩種方法。試驗A係將藥劑混合於木屑包中（木屑包成份爲雜木屑：米糠：水=25：8.3：66.7(w/w)）木屑包並用碳酸鈣調整其pH值爲 5.4，每包

重1,000g，並以低溫常壓（96～98°C）殺菌 4 小時，後於 20°C時接種香菇菌絲，並在24°C下培養。試驗B則於每包木屑培養基中同時加入2ml之 *Trichoderma* spp. 孢子混合液（濃度爲7500個孢子/ml）），孢子混合液爲*T. viride*及*T. harzianum*之孢懸浮液以等量混合。未接種雜菌（處理A）於接種香菇菌絲40天後調查，接種雜菌者（試驗B）則於接種後二星期及五星期各調查一次。調查項目包括菌絲長度，雜菌種類及數量，以及是否形成原基體（primordium）或癒合狀組織（callus-like tissue）。菌絲生長勢則依下列公式計算，且各項調查以平均值表示。

$$菌絲生長勢（\%）=\frac{菌絲生長長度（cm）}{木屑包長度（cm）}\times 100$$

七、各藥劑處理對香菇產量之影響：將由前項處理後之木屑包按一般香菇栽培管理方法進行管理，並於出菇後採取八分開子實體稱其鮮重及乾物重量，共採收四次。並比較其間之差異及藥劑是否會影響產量，以100包爲計算單位，若未達100包則以100包計算。

結 果

一、藥劑之篩選：供試之五種原廠生產之藥劑經室內藥效試驗，發現當濃度爲50ppm時均無抑制效果，但除Benomyl外，在200ppm之濃度時均可抑制 *Trichoderma* spp. 菌絲之生長(表 2，圖 1），Benomyl在 400ppm時對可抑制 *Trichoder ma* spp. 之生長。

二、藥劑對香菇菌絲生長之影響：當藥劑濃度增加到某種程度時對香菇菌絲之生長即有影響，如Tecto-45在 1,000ppm以上時則有顯著之影響，但在同一濃度下其他藥劑則沒有顯著影響（表 3）。Penmush（=Y101）在500倍（2000ppm）及2000倍（500ppm）時對香菇菌絲之生長影響比較時發現 500倍液使得香菇菌絲生長較爲遲緩且菌絲量少（圖 2，A），200倍液則與未加藥劑者相似（圖 2，B及C）。

三、木屑雜菌防治試驗：由於*Trichoderma* spp. 在木屑包製作過程中發生率較高，而TBZ系統藥劑具有耐高溫特性，因此未接種雜菌及未加藥劑之木屑包經殺菌後其雜菌自然發生之比例爲 14%（表 4，處理10)，但若加入藥劑再經殺菌，則可降到 4 %以下，且香菇菌絲不受影響（表 4 之處理 1 及 2 除外）。在表 5 中，接種雜菌二星期後除處理 4 及12外，均有良好之抑制雜菌效果，但如果繼續培養至五星期後，則除了處理 5，7，8 外均無良好防治及效果（表 6），其中以處理 5 及 7 之防治效果較好。處理 5 即Penmush（=Y101），日本製造，每包用量0.2g • 處理 7 即Tecto-60，每包用量0.2g二者對香菌絲生長無害。而雜菌在木屑包發生情形可由第一次調查中看出，即未加藥劑而接種雜菌有97%之發生率（表 5），若繼續培養到五星期則發生率爲 100%（表 6）。

四、藥劑處理對子實體產生之影響調查：調查經藥劑處理後之木屑包其子實體產生情形，發現在正常管理下，每包重1,000g之木屑包若未加藥劑可產生 161g 之鮮子實體，佔木屑包重量之14%。但若木屑包中接種雜菌則全無收穫。當以藥劑加入後，除了處理 9 及13稍有影響外，其他處理（經調查之處理，如表 7 所示）則與對照（不加藥劑）相近，因此藥劑Penmush（=Y101）及Tecto-60在使用上對出菇無影響（圖 3）。而在香菇體之平均收縮率而言，相差也不大，範圍在6.8～8.0：1 與對照之7.4：1 相近。

討 論

在香菇生產過程中，菌絲之培養期佔有很重要的地位，尤其是目前本省所用之栽培材料均爲木屑，其來源並不單純，在木屑中常夾雜許多含油類物質或含有防腐劑。因此許多栽培者常以適合香菇生長之樹種枝幹來碾碎後供菌絲培養用，但若此種木屑中含有蟲蛀口或腐爛部份甚至帶有雜菌則對以後之菌絲培養有很大影響，因此在木屑選擇時應特別小心以確保日後製造木屑包或菌種時之品質。雖然木屑培養基經過殺菌後可以將大部份微生物殺死，但無法全部殺滅，尤其在低溫大規模殺菌時更爲明

表2. 各種藥劑對*Trichoderma viride*及*T. harzianum*之生長抑制作用[a]

Table 2. Effect of fungicides at different concentrations on the growth of *Trichoderma viride* and *T. harzianum*

藥劑 Fungicide	藥劑濃度 Fungicide concentration (ppm)[d]																	
	50		100		200		400		500		1,000		2,000		4,000		5,000	
Tecto-45	+[b]	+[c]	±	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
Tecto-60	±	±	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
Penmush (=Y101)	±	±	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
Mertect-340	+	+	±	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
Benomyl	+	+	+	±	±	±	−	−	−	−	−	−	−	−	−	−	−	−
CK	雜菌菌絲長滿																	

a. "−"表示*Trichoderma* spp. 菌絲無法生長，並死亡；"±"表示停止生長但未死亡；"+"表示正常生長。
Mycelial growth : "+"=normal growth ; "−"=could nort gorw and dead ; "±"=could not grow but not dead.

b. 本項爲對*T. viride*之抑制結果。
The result of *T. viride*

c. 本項爲對*T. harzianum*之抑制結果。
The result of *T. harzianum*.

d. 此爲接種14天後之觀察結果。
The mycelial growth of *Trichoderma* spp. after 14 days on PDA plate.

表3. 不同濃度之藥劑對香菇菌絲生長之影響[b]

Table 3. Effect of fungicides on mycelial growth of shiitake (*Lentinus edodes*)

藥劑 Fungicide	藥劑濃度 Concentration (ppm)								
	50	100	200	400	500	1,000	2,000	4,000	5,000
Tecto-45	8.0	7.9	7.9	7.7	7.0	4.7	4.3	4.3	4.0
Tecto-60	8.0	8.0	7.8	7.7	7.4	7.3	7.0	6.7	6.5
Penmush (=Y101)	8.0	7.8	7.8	7.4	7.3	7.3	7.2	6.8	6.5
Mertect-340	8.0	7.5	7.3	7.2	7.0	7.0	6.8	6.4	6.3
Benomyl	8.0	7.8	7.5	7.4	7.2	7.0	6.8	6.6	6.2
CK[a]	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0

a. CK：只接種香菇菌絲而不加藥劑
CK : only shiitake mycelia was inoculated, no fungicide treatment.

b. 香菇菌落直徑爲四重複之平均値（公分）
The diameter of shiitake colonies were based on the mean of 4 PDA plates in each treatment.

表4. 試驗A雜菌發生之調查，本試驗未接種*Trichoderma* spp.

Table 4. Survey of contamination from Test A which no *Trichoderma* spp. were inoculated.

處理 Treatment	總數（包）Total (bag)	生長勢(%) Growth rate (%)	產生原基體 Primordium formed	健全 Healthy	感染率(%) Infection (%)	綠黴菌 *Trichoderma* spp.	紅麵包黴菌 *Neurospora* spp.
1	160	23	—	157	2	2	1
2	160	26	—	153	4	5	2
3	160	96	—	158	1	2	0
4	160	96	+	157	2	2	1
5	160	95	+	159	1	0	1
6	160	88	+	159	1	0	1
7	160	92	+	159	1	0	1
8	160	94	—	158	1	0	2
9	160	94	—	150	6	2	8
10	160	95	+	138	14	18	4
11	160	92	—	155	3	3	2
12	160	88	—	154	4	3	3
13	160	87	—	154	4	5	1

表5. 試驗B雜菌發生之第一次調查，本試驗接種*Trichoderma* spp.

Table 5. The first survey of contamination from Test B in which *Trichoderma* spp. were inoculated.

處理 Treatment	總數（包）Total (bag)	健全 Healthy	綠黴菌 *Trichoderma* spp.	紅麵包黴菌 *Neurospora* spp.	黃麴菌 *Aspergillus* spp.
1	160	150	6	3	1
2	160	146	12	2	0
3	160	140	18	2	0
4	160	111	46	3	0
5	160	156	1	2	1
6	160	152	7	1	0
7	160	156	4	0	0
8	160	148	7	5	0
9	160	144	8	5+(2)	1
10	160	5	155	—	—
11	160	95	59	6	0
12	160	4	148	8+(6)	0
13	160	144	13	3	0

* 括號內數字表示同時發生綠黴菌而且已計算於綠黴菌中。

The number in the parenthesis indicated that *Trichoderma* spp. also was observed and included in the counting of *Trichoderma* spp.

表6. 試驗B雜菌發生之第二次調查*

Table 6. The 2nd survey of contamination from Test B inwhich *Trichoderma* spp. were inoculated.

處理 Treatment	總數(包) Total (bag)	生長勢(%) Growth rate(%)	產生原基體 Primordium formed	健全 Healthy	** 感染率(%) Infection (%)	綠黴菌 *Trichoderma* spp.	紅麵包黴菌 *Neurospora* spp.	黃麴菌 *Aspergillus* spp.
1	160	—	—	9	94 a	151	(4)***	0
2	160	—	—	4	97 a	156	(3)	0
3	160	—	—	10	94 a	150	(3)	0
4	160	—	—	5	97 a	154	(4)	1
5	160	95	+	155	3 c	5	(3)	0
6	160	88	+	57	64 b	102	1	0
7	160	94	—	144	10 c	15	1	0
8	160	90	+	116	28 c	44	(5)	0
9	160	89	—	58	64 b	102	(8)	0
10	160	—	—	0	100 a	158	2+(1)	0
11	160	—	—	1	100 a	153	5+(18)	1
12	160	—	—	0	100 a	156	4+(22)	0
13	160	87	—	86	46 b	74	(8)	0

*生長勢以健全者計算，發生雜菌者不包括在內。

Growth rate was based on the healthy bag and not included the contaminated bag.

**小寫英文字母相同者為依鄧肯氏多變域測驗法在LSD 1%下不顯著者。

Whitin columns, mean followed by the same letters are not significantly different (p=0.01) according Duncan's multiple range test.

***括號內數字表示同時發生綠黴菌且已計算於綠黴菌項中。

The number in the parenthesis indicated that *Trichoderma* spp. also was observed and included in the counting of *Trichoderma* spp.

表7. 藥劑對香菇產量之影響*

Table 7. Effect of fungicides on the yield of shiitake.

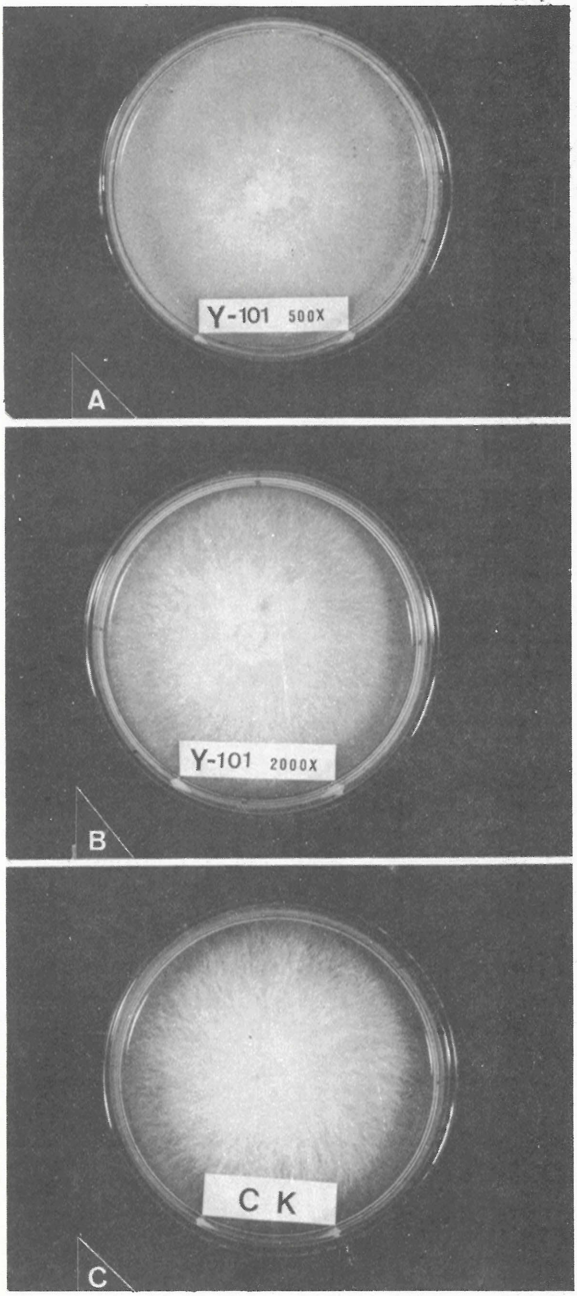
處理 Treatment	藥劑及用量(克/包) Fungicide and dosage (g/bag)		產量(克/包)** Yield (g/bag) 試驗A Test A 鮮重 Fresh wt.	試驗A Test A 乾重 Dry wt.	試驗B Test B 鮮重 Fresh wt.	試驗B Test B 乾重 Dry wt.
5	Penmush (=Y101)	0.2	164 a	24 a	162 a	24 a
6	Penmush (=Y101)	0.12	155 a	23 a	154 a	23 a
7	Tecto-60	0.2	158 a	23 a	155 a	21 a
8	Mertect-34	0.3	150 ab	21 a	152 a	21 a
9	Mertect-340	0.2	148 b	20 a	146 b	19 b
10	CK	—	161 a	22 a	0 c	0 c
13	Benomyl	0.2	146 b	19 b	144 b	18 b

*各數字為100包八分開香菇子實體之平均結果。

Data were based on the average of eighty percent opened fruiting bodies of shiitake of on hundred bags.

**小寫部份英文字母相同者為依鄧肯氏多變域測驗法在LSD 1%下不顯著者。

Within columns, mean followed by the same letters are not significantly different (p=0.01) according Duncan's multiple range test.



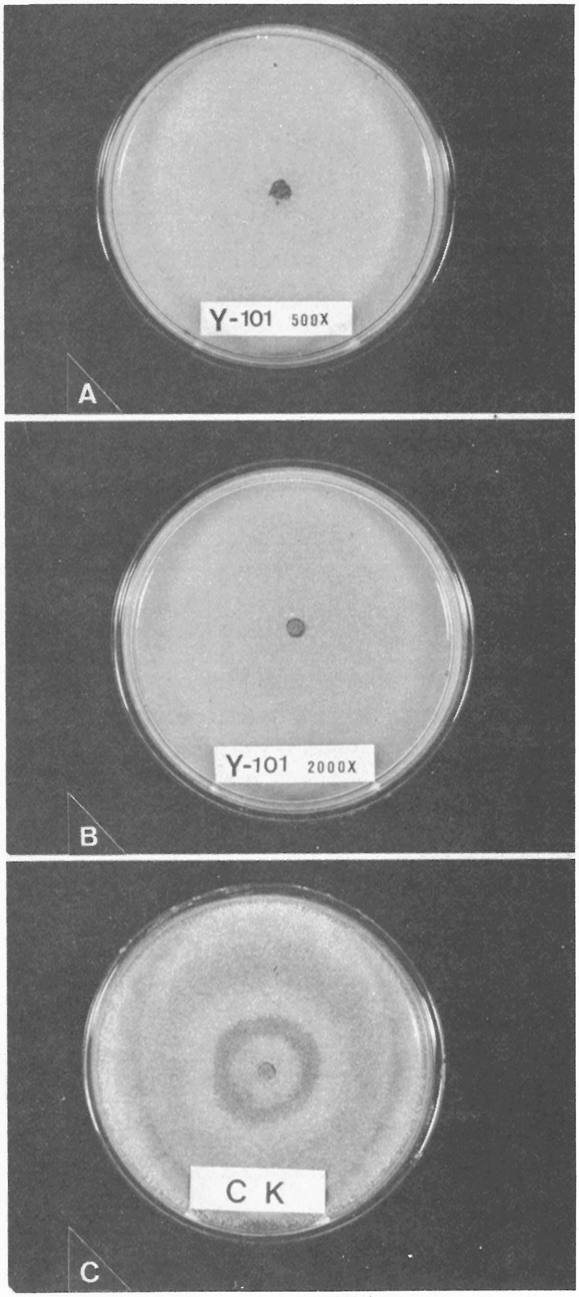
圖一、Penmush (＝Y101) 對*T. viride*菌絲生長之抑制效果

A. 500倍 (2000ppm) 時，B. 2000 倍 (500 ppm)，C. 對照 (不加藥劑)

Fig1. The inhibition of Penmush (＝Y101) on mycelial growth of *T. viride*

A. 500× (2000ppm).B. 2000× (500ppm).

C,CK (non−treated control)



圖二、Penmush (＝Y101) 對 *Lentinus edodes* 菌絲生長之影響

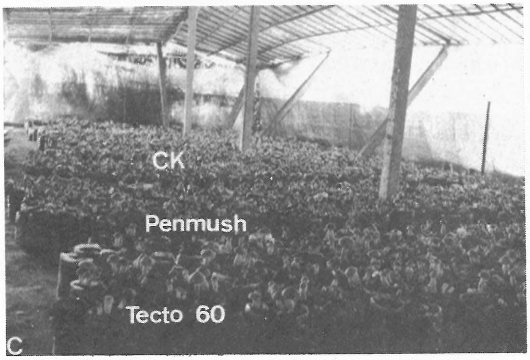
A. 500倍 (2000ppm).B. 2000倍 (500ppm).

C. 對照 (不加藥劑)

Fig2. The effect of Penmush (＝Y 101) on mycelial growth of *Lentinus edodes*.

A. 500× (2000ppm).B, 2000× (500ppm).

C. CK (non−treated control)



圖三、香菇在添加藥劑之木屑包出菇情形

A. 添加Penmush（＝Y101）0.2g/包，B. 添加Tecto-60 0.2g/包， C. 與對照（不加藥劑）之比較

Fig3. The fruiting body formation of *Lentinus edodes* on sawdust bags mixed with fungicides.

A. 0.2g/per bag Penmush（＝Y 101）was added. B. 0.2g/per bag of Tecto-60 was added. C. Comparing with CK in which no fungicide was added.

顯，因此雜菌之防除工作至爲重要。而在藥劑之使用上除考慮其毒性外，其安定性也很重要，尤其在高溫高壓下之安定性， TBZ 系統之藥劑均有耐高溫高壓而可保持安定之特性。在本試驗中發現以藥劑加入培養基中則在 50ppm 時只有 Penmsh（＝Y101）及 Tecto-60 其有抑制作用，而濃度提高到200ppm時除 Benomy外均具有對*Trichoderma* spp. 之殺菌能力（表 2）。在Fukai[3]的試驗中發現Benomyl若用於珍珠菇栽培時，在木屑中加入10ppm即可抑制 *T. viride*之生長。但在Ogawa[23]之試驗卻發現 Benomyl 混合於木屑中使用時，若爲珍珠菇栽培則用量爲 100～500ppm 才有抑制 *T. viride* 的效果。在珍珠菇而言，二者結果相差10倍以上，是否 *T. virid* 已產生抗 Benomyl 之特性抑或其他原因未明。在本省而言，*T. viride*及*T. harzianum* 是否對 Benomyl具有抗藥性也沒有正式報告。在所有的藥劑試驗中發現 50ppm 以上才可抑制 *Trichoderma* spp. ，而在木屑中加入Penmush（＝Y101）或 Tecto-60 ，其用量爲 0.2g/包 ，即 200ppm 時具有良好之抑制效果（表 4、5、6），且對香菇菌絲無影響， 對產量也沒有害處（表 7） 。而在培養基試驗時 100ppm 之Tecto-45對香菇菌絲生長即有影響，其他藥劑則無，但濃度提高到 4,000ppm時，則各藥劑均有顯著影響，由此可知藥劑雖可抑制雜菌，但在高濃度下對香絲菌絲生長仍爲不利，在使用上應特別注意，不可過量。

一般在未接種雜菌及未加入藥劑之木屑包，經過殺菌後其自然發生雜菌之比例爲14%，因此低溫殺菌對雜菌仍無法完全去除，尤其在木屑中若含有高濃度之雜菌時更爲危險。另在本省自行配製之藥劑中，如處理1（Mertect-340每包 0.3g）及 2（Mertect-340每包 0.2g）成份相同，但殺菌能力卻無法表現出來，可能是其添加物影響所致 ，而分裝藥劑如處理 3（Mertect-340 ，每包0.3g）及 4 (Mertect-340，每包 0.2g) 也有類似情形，若能在這方面加以改進則在本省配製下將可降低價格以嘉惠農民。此種情況也顯示本省農藥在配製上仍有某種程度之困難，此點應加以克服。在抗藥性方面，徐氏(8)曾對 Benomyl進行試驗，發現其對洋菇褐痘病易導致抗藥性，因此除了以 Benomyl來作爲香

菇之雜菌防治藥劑外，亦應選用其他藥劑或開發新的藥劑也是目前極重要的工作。

雖然Penmush（＝Y101）及Tecto-60均屬於TBZ系統藥劑，且在日本 TBZ 爲食品添加劑之一種，而且毒性極低，殺菌範圍廣，易排出人體，但在本省而言，其殘留情形仍需進一步試驗，以確保吾人之健康。由本試驗知，Penmush（＝Y101）及 Tecto-60若以每包木屑包重量爲 1,000g時加入 0.2g 的劑量則可抑制絕大部份香菇雜菌之發生，且對香菇菌絲及出菇無影響。而蒸氣殺菌仍爲殺滅木屑中微生物之最好方法，但在後期的感染發生仍有賴於藥劑之防治，因此若能施以良好的蒸氣殺菌再配合藥劑之混合於木屑包中使用，則可避免絕大部份雜菌之發生。

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Efficacy of Fungicides on the Control of *Trichoderma* spp. in Sawdust Cultivation of Shiitake[1]

Ying-ming Liao[2]

Summary

The efficacy of fungicides Penmush (=Y101), Mertect-340, Tecto-45, Tecto-60 and Benomyl against contamination of *Trichoderma* spp. in sawdust cultivation of Shiitake (*Lentinus edodes* (Berk.) Sing) were evaluted on potato dextrose agar (PDA) and sawdust media. Fungicides were seperately mixed into PDA or sawdust at various concentrations and then *Trichoderma* spp. were inoculated. The isolates of *Trichoderma* were obtained from contaminated bag of different shiitake farms. The efficiency was based on the mycelial growth rate of *Trichoderma* spp. on PDA plates and/or on sawdust in plastic bags. Effective fungicides from the preliminary experiments were selected and used in the advanced trials in sawdust method. After incorporation of fungicide and inoculation of *Trichoderma* spp. in sawdust bags. Agar disc of Shiitake mycelial also were inoculated to evaluate the effect of fungicide on the mycelial growth of Shiitake. The result of the experiments were summarized as follow:

(1) At the concentration of 50 ppm, only Penmush and Tecto-60 were able to inhibit the growth of *Trichoderma* spp. among the five fungicides tested. If the concentration is higher than 400ppm all tested fungicides were found effective.

(2) No significantly harmful effect of the 5 fungicides on the mycelial growth of shiitake were observed up to the concentration of 2,000ppm besides Tecto-45.

(3) If fungicide Penmush or Tecto-60 were mixed into sawdust before sterilization, 98% of sawdust bag were observed without contamination of *Trichoderma* spp. in the first two weeks after sterilization and 97% and 90% of control for Penmush and Tecto-60, respectively, were recorded after 5 weeks.

(4) The concentration studies showed that at the level of 0.2g (200 ppm) per-sawdust bag was the best because it performed good control of *Trichoderma* spp. and did not inhibit the mycelial growth of Shiitake. However, it didn't increase the yield.

(5) This studies indicated the fungicides Penmush (=Y101) and Tecto-60 were effective to control the contamination of *Trichoderma* spp. and can be used in the sawdust cultivation of Shiitake

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小菜蛾幼蟲寄生小繭蜂（*Apanteles plutellae*）之重複寄生蜂[1]

錢景泰　邱瑞珍[2]

摘要：小菜蛾幼蟲寄生小繭蜂（*Apanteles plutellae* Kurdj., Braconidae）乃小菜蛾（*Plutella xylostella* Linn., Plutellidae）之重要天敵，本所曾大規模繁殖，釋放於蔬菜示範專業區防治小菜蛾。筆者等於民國 61 年發現其有重複寄生現象，乃進行其重複寄生種類、寄生率及寄生情形等之調查。

本文敍述小菜蛾之重複寄生蜂 10 種，均屬本省新記錄。其名稱與寄生率分別爲素木金小蜂(*Trichomalopsis shirakii*), 13.66%；刺姬蜂(*Diatora prodeniae*), 2.05%；圓腹卵蜂（*Calliceras* sp.), 0.97%；絨繭金小蜂（*Trichomalopsis apanteloctena*), 0.09%；金小蜂（*Trichomalopsis* sp.), 0.08%；菱室姬蜂（*Stictopisthus* sp.), 0.05%；溝姬蜂（*Gelis* sp.), 0.04%；廣肩小蜂（*Eurytoma* sp.), 0.02%；大腿小蜂（*Brachymeria* sp.), 0.01%及扁股小蜂（*Elasmus* sp.), 0.01%。並發現素木金小蜂與刺姬蜂之成蜂有取食寄主體液而使之致死之習性。至於其重複寄生率（hyperparasitism）在施藥之小面積菜園約達 26.3%，收穫後之蔬菜殘株上約達 46.2%。不施藥之網室菜園，在小菜蛾小繭蜂結繭之初期，其被重複寄生者約 3.1%，2 個半月後約高達 53%。

小菜蛾（*Plutella xylostella* Linn., Plutellidae）乃本省十字花科蔬菜之重要害蟲，因每年發生多達20餘世代，用藥次數頻繁，對目前推廣之農藥如加保扶（carbofuran）、美文松（mevinphos）、培丹（cartap）、百滅靈（permethrin）及芬化利（fenvalerate）等已產生中度至嚴重之抗藥問題[10]，因此本省對小菜蛾之防治除致力於有效藥劑之試驗，對其天敵之利用亦加强研究之。

小菜蛾寄生性天敵依文獻記載計有 42 屬，126種[6]。但就本省而言，較重要者僅菜蛾小繭蜂（*Apanteles plutellae* Kurdj., Braconidae）1 種，寄生於其幼蟲，其田間寄生率爲27-37.5%[2,5,8]。民國 61 年7月本所因配合前農復會補助進行小菜蛾之綜合防治試驗，曾大量繁殖該蜂，釋放於田間以防治小菜蛾。依採得之菜蛾小繭蜂估計，其被重複寄生者爲數不少，茲爲報導此類重複寄生蜂對於菜蛾小繭蜂之寄生情況、發生密度、季節消長以及其對菜蛾小繭蜂族羣密度之抑制程度，乃將所獲資料整理如後，備供利用該蜂防治小菜蛾之參考。

材料與方法

菜蛾小繭蜂之重複寄生蜂種類及其寄生率之調查

民國 62 至 63 年於本省北部蔬菜栽培區之竹子湖、陽明山、板橋、士林、樹林、龜山、三重、

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1. 臺灣省農業試驗所　研究報告第1237號。本文承本系副研究員林珪瑞鑑定部分寄生蜂學名，吳幹成、萬小琳繪圖，劉成功、陳嬌娥協助採集與飼蟲，謹附此致謝。

2. 本所應用動物系助理研究員、研究員。臺灣省　臺中縣　霧峰鄉。

蘆州、永和、中和、公舘、景美以及本所前臺北舊址網室菜園等地採集菜蛾小繭蜂之繭携回室內飼育。其中少部分蜂繭係供室內繁殖用，大部分則以 7°C 恆溫冷存供釋放於士林、竹北、西螺、永靖、楠梓及路竹等蔬菜示範專業區以防治小菜蛾。放蜂時，將蜂繭裝入特製之竹筒內，插在各地菜園[7]。蜂繭因係採自野外或田間網室，故均有被重複寄生之可能。留種用者待其羽化後，檢視其被重複寄生之種類與寄生率，而釋放用者則須待釋放2星期後收回竹筒，檢查菜蛾小繭蜂之重複寄生種類與寄生率。

菜蛾小繭蜂正常羽化時必定留下帶有繭蓋之空繭，而被重複寄生蜂寄生過之蜂繭則無此現象。但可依其羽化孔之位置、大小，以及繭內殘留之繭或蛹殼等特徵而判別其種類。不能羽化之蜂繭亦予以剖視，以確定其是否被重複寄生。

菜蛾小繭蜂重複寄生蜂類之習性觀察

在溫度 28°C、75% RH, 12 hr 照明之室內將所採得之重複寄生蜂分別接種於菜蛾小繭蜂繭內之老熟幼蟲或蛹，以確定其是否爲重複寄生物，並觀察其寄生經過。採得數量過少而無法接種進行觀察者，則剖視其繭，記述其寄生情況。

菜蛾小繭蜂與其重複寄生蜂發生消長之調查

62 年 10 月與 63 年2月先後2次分別在 0.05 ha 之不施藥網室菜園內繁殖小菜蛾及其寄生小繭蜂。第一次因受陰雨影響，繁殖工作不甚理想，2個半月共繁殖得蜂繭 7,227個。第二次飼育因受低溫與雨天之影響，半個月內僅繁殖得蜂繭 1,652個，後又因多雨，甘藍根部腐爛，繁殖小菜蛾與其小繭蜂之工作方陷于停頓。所幸在2次繁殖菜蛾小繭蜂之同時均採集小繭蜂繭進行其重複寄生蜂之發生消長調查，故將資料加以整理與記述。

結　果

菜蛾小繭蜂重複寄生蜂之種類與寄生率

62 至 63 年在本省北部蔬菜栽培區與本所前臺北舊址之網室菜園採集得菜蛾小繭蜂繭 10,770 個，經仔細檢視發現有 10 種重複寄生蜂，分隸於6科8屬。其中多數蜂因鑑定困難而且部分可能爲新種，或屬本省新記錄種，故目前僅能鑑定其屬名，可使用下列之檢索表加以區分。其中以素木金小蜂 (*Trichomalopsis shirakii*)，刺姬蜂 (*Diatora prodeniae*) 及圓腹卵蜂 (*Calliceras* sp.) 較爲普遍，其餘之寄生率約在 0.1%以下（表1）。

菜蛾小繭蜂之重複寄生蜂檢索表

1.觸角絲狀，鞭節 (flagellum) 19-29 環節。成蟲有翅或無翅，有翅者翅脈相頗發達，具6-7室。體軀最長約3.1 mm。……………………………………………………… 2

觸角膝狀，鞭節最多11環節。成蟲有翅，翅脈相當退化，無翅室。體軀最長約 2.6 mm。………4

2.前翅之小翅室 (areolet) 菱形。體色黃。後足兩脛節距 (tibial spur) 長度不相等。雄性生殖器之把握器(clasper)延伸成細長棍棒狀。體長約 3.1 mm。…菱室黃姬蜂 (*Stictopisthus* sp.)

前翅小翅室不存在。體黑色或紅褐色。後足兩脛節距等長。雄性生殖器之把握器不呈棍棒狀。……………………………………………………………………………… 3

3.成蟲有翅。前胸背板 (pronotum) 漆黑色、光澤，有極稀之刻點。腹部黑色，第二腹節背板 (tergite) 有黃斑。體長約 2.5 mm。…………………………刺姬蜂 (*Diatora prodeniae*)

雌成蟲無翅。前胸背板赤褐色、無光澤，有圓形細織紋(mat)。腹部黑色，第一腹節背板全部、第二腹節背板部分呈黃褐色。體長約 3.0 mm。…………………………溝姬蜂 (*Gelis* sp.)

4.前胸背板伸達翅蓋 (tegula)。雌蟲產卵管自腹部末端伸出。體長約 1.2 mm。…………………………………………………………………… 圓腹卵蜂 (*Calliceras* sp.)

前胸背板不伸達翅蓋。雌蟲產卵管自腹部末端前方伸出。…………………………………………… 5

5.後足腿節特粗大。或前胸背板近橫長方形。…………………………………………………… 6

後足腿節正常。前胸背板不呈橫長方形。…………………………………………………………… 7

6.前胸背板短寬。後足基節長，約爲前足基節之 7 倍，腿節粗大，下緣有齒狀，脛節彎曲。體長約 2.0 mm。………………………………………………………大腿小蜂 (*Brachymeria* sp.)

前胸背板近橫長方形。後足基節短，與前足基節等長，腿節與脛節均正常，不如上述。體長約 2.2 mm。………………………………………………………… 廣肩小蜂 (*Eurytoma* sp.)

7.跗節 4 節，後足基節擴大、扁平如碟狀。前翅顯著狹長如楔形。雄蟲觸角有側分枝。體長約 1.4 mm。…………………………………………………………扁股小蜂 (*Elasmus* sp.)

跗節 5 節，後足基節正常。前翅正常形。雌、雄蟲之觸角鞭節均呈棍棒狀。體長 0.8–2.0 mm。……………………………………………………………………………………………… 8

8.體金綠色。顳顬 (temple) 寬約複眼長之 ½。上唇基片 (clypeus) 上之縱條紋幾乎延伸至複眼下緣及顎基間部 (malar space)。體長約 2.0 mm。………………………………………………………………………………………… 絨繭金小蜂 (*Trichomalopsis apanteloctena*)

體暗綠色。顳顬寬約複眼長之 ¼。上唇基片上之縱條祇限於上唇基片區。體長約 0.8–2.0 mm。……………………………………………………………………………………………… 9

9.左大顎 (mandible) 有 3 齒，右大顎有 4 齒。足黃褐色，基節棕黑色。體長 1.5–2.0 mm。……………………………………………………………素木金小蜂 (*Trichomalopsis shirakii*)

左、右大顎各有 3 齒。足黃色，基節同色。體長約 0.8 mm。……金小蜂 (*Trichomalopsis* sp.)

表1. 菜蛾小繭蜂之重複寄生蜂 (1973–1974)

Table 1. Hyperparasitoids of *Apanteles plutellae* (1973–1974)

寄生蜂 Parasitoids	寄生率 % Parasitism	寄生形式 Type of parasitization
姬蜂科 (Ichneumonidae)		
**Diatora prodeniae*	2.05(1.60– 4.05)	單元，體外寄生。
Gelis sp.	0.04(0 – 0.05)	單元，體外寄生。
Stictopisthus sp.	0.05(0 – 0.16)	單元寄生。
大腿小蜂科 (Chalcididae)		
Brachymeria sp.	0.01(0 – 0.05)	單元寄生。
廣肩小蜂科 (Eurytomidae)		
Eurytoma sp.	0.2 (0 – 0.10)	單元寄生。
金小蜂科 (Pteromalidae)		
Trichomalopsis apanteloctena	0.09(0 – 0.42)	單元寄生，偶有 1 繭內有 2 隻蜂。
**T. shirakii*	13.66(11.70–22.50)	單元，體外寄生。
Trichomalopsis sp.	0.08(0.02– 0.37)	單元寄生。
扁股小蜂科 (Elasmidae)		
Elasmus sp.	0.01(0 – 0.05)	單元，體外寄生。
圓腹卵蜂科 (Ceraphronidae)		
**Calliceras* sp.	0.97(0.30– 1.10)	多元，體外寄生。

* 普遍發生之種類 (commonly occurred species)。

菜蛾小繭蜂重複寄生蜂之發生消長

分析 62 至 63 在北部蔬菜栽培區之採集結果，得知 8、9 月時菜蛾小繭蜂之蜂繭僅能在氣溫較低

之陽明山、竹子湖一帶已經採收之甘藍殘株上採得，其重複寄生率為 40.6-59.3 %。平地蔬菜栽培區因甘藍種植較晚，且在菜農之周密管理下，幾乎難以發現有小菜蛾之發生，故寄生蜂之蜂繭僅在10月上旬至次年6月間於小面積菜園陸續有零星之發現。其重複寄生率在 10 至 12月 分別為 12.1、11.0 及 22.4% 外，其餘5個月份均維持在 30% 左右（圖1）。

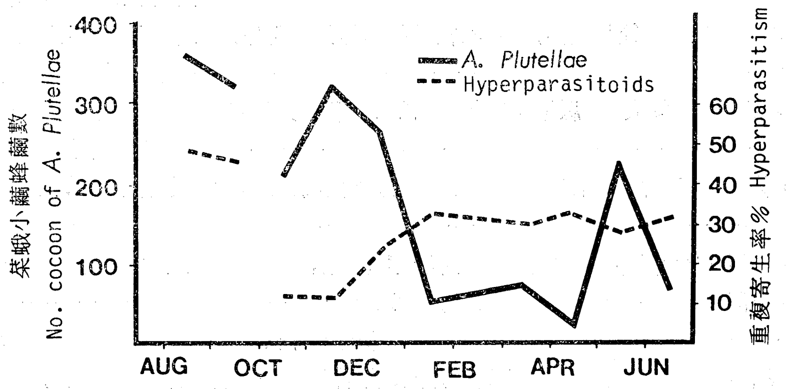

圖1. 本省北部蔬菜栽培區菜蛾小繭蜂與其重複寄生蜂之發生（1973-1974）

Fig. 1. Occurrence of *Apanteles plutellae* and its hyperparasitoids in cruciferous vegetable fields in northern Taiwan (1973-1974).

菜蛾小繭蜂重複寄生蜂之習性觀察

刺姬蜂 (*Diatora prodeniae*, 圖 2)

該蜂屬姬蜂科（Ichneumonidae）。雌蜂產卵時，不停敲打觸角，遇上菜蛾小繭蜂繭時，即在其上往返爬行並敲打數次，後將體軀抬高，兩翅平放，腹部下彎與體軸略成直角，並藉產卵管鞘之支持將產卵管作試探性地刺入小繭蜂內，待刺入成功時，即行產卵。每次產卵需時1分 25 秒至3分 45 秒，平均約2分 30 秒。卵產於寄主繭內老熟幼蟲或蛹之體表。每繭產下1卵或數卵，但祇有1卵能夠孵化。

卵為長圓形，一端略尖，初產時為黃色，後色漸淡。初齡幼蟲體細長，無色透明，至四齡時變為淡黃色、半透明、體呈紡錘形。幼蟲孵化後在寄主體表爬行、取食。至四齡老熟時，其胴體已占據寄主繭之全部，隨即化蛹。前蛹與蛹均為淡黃色。

成蜂羽化時在其寄主繭之一端附近咬一直徑約 0.7 mm 之羽化孔而出。繭內僅留寄主皮囊與黑色蛹便。

在室溫 28°C、75% RH 飼育該蜂，完成1世代約需 18 天。計卵期 1.5 至2天。幼蟲期約 9.5 天，第一至四齡幼蟲之發育期分別為 2.5、1、2 及 4 天。前蛹期2天。蛹期5天。成蟲羽化後飼以 20 %蜜水，其壽命約為10天。

雌蜂除產卵寄生於菜蛾小繭蜂外，尚發現其用產卵管在寄主繭內作多次鑽刺，約4-5分鐘後拔出產卵管，立即湊上口器吮吸寄主繭內老熟幼蟲或蛹之體液，經2-3秒後，略作休息並清理口器，再度刺吸，如此重複數次，為時 11-14 分鐘。被吸食過之繭，在放大鏡下可以見到被其產卵管刺過之小孔，其四周遺留有黃色至褐色之寄主乾涸體液痕跡。此時寄主已經死亡，因此其體表若附有該蜂產下之卵粒，亦不會孵化。

該蜂在北部蔬菜栽培區均可採得。

溝姬蜂 (*Gelis* sp., 圖 3)

該蜂屬姬蜂科（Ichneumonidae）。雌蜂無翅，祇能靠爬行尋覓寄主。產卵後幼蟲營單元體外寄生。寄生蜂幼蟲老熟時寄主體內物質已被消耗殆盡，於是幼蟲緊依著寄主繭另結1無色透明之薄繭而化蛹。成蜂羽化時在寄主繭之一端 0.34 mm 處咬一直徑約 0.75 mm 之羽化孔而出。繭內留有寄主之老熟幼蟲皮囊及黑色蛹便。

該蜂係於 63 年 2 月間在公舘菜園採得之菜蛾小繭蜂繭羽化得5隻雌蜂，雄蜂未採到。

菱室姬蜂（*Stictopisthus* sp.，圖5）

該蜂屬姬蜂科（Ichneumonidae）。爲單元寄生。幼蟲化蛹時，其寄主體之內容物已被消耗殆盡，寄生蜂幼蟲乃緊依著寄主之繭另結一無色透明之薄繭而化蛹。成蜂羽化時在繭之一端咬一直徑約 0.68 mm 之羽化孔而出。繭內留有寄主老熟幼蟲之皮囊及黑色蛹便。

該蜂係於 62 年 11 月自公舘、板橋及 63 年1－2月自公舘、龜山等地菜園採得之菜蛾小繭蜂繭羽化得4雌、2雄。

大腿小蜂（*Brachymeria* sp.，圖4）

該蜂屬大腿小蜂科（Chalcididae）。爲單元寄生。成蜂羽化時在繭之一端 0.5 mm 處咬一直徑約 0.85 mm 之羽化孔，破繭而出。

該蜂係於 62 年4月在蘆州菜園採得之菜蛾小繭蜂繭飼育得1隻雌蜂。

廣肩小蜂（*Eurytoma* sp.，圖6）

該蜂屬廣肩小蜂科（Eurytomidae）。爲單元體外寄生。成蜂羽化時在繭之一端 0.14 mm 處咬一直徑約 0.7 mm 之羽化孔，破繭而出。繭內留有該蜂之褐色蛹殼、黑褐色蛹便及寄主之皮囊。

該蜂係於 62 年9月在陽明山與 63 年6月在景美菜園採得之菜蛾小繭蜂繭羽化得2隻雌蜂。

絨繭金小蜂（*Trichomalopsis apanteloctena*，圖7）

該蜂屬金小蜂科（Pteromalidae）。爲單元寄生，或偶有多元寄生。成蜂羽化時在繭之端部或其側緣 0.2-0.4 mm處咬一直徑 0.7-0.9 mm之羽化孔，破繭而出。若1個繭內有2隻蜂寄生，則各自繭之一端咬一直徑約 0.7 與 0.9 mm之羽化孔外出。繭內遺留該蜂淡黃褐色之蛹殼、蛹便及寄主遺骸。

該蜂係於陽明山、板橋、公舘等地菜園採得之菜蛾小繭蜂繭羽化得雌、雄蜂多隻。

素木金小蜂（*Trichomalopsis shirakii*，圖8）

該蜂屬金小蜂科（Pteromalidae）。雌蜂揮動觸角尋找菜蛾小繭蜂之繭產卵。每次產卵時間 5－8分鐘。卵產在剛結繭之寄主老熟幼蟲或蛹之體表。對於已被產過卵之蜂繭，常再次產卵，但僅有1卵能够孵化。

卵爲茄形，無色半透明。初齡幼蟲形細長，無色透明，二齡時呈半透明。幼蟲孵化後即在寄主體表爬行取食。四齡幼蟲爲紡錘形，發育至此時，寄主體已萎縮，寄生蜂即在寄主繭內化蛹。前蛹爲乳白色，蛹爲淡褐色。成蜂大部分在繭之一端 0.34－0.85 mm 處咬一直徑 0.45－0.85 mm 之羽化孔外出。少數羽化孔位置僅距繭端約 0.17 mm 或遠達 1.19 mm。繭內留有該蜂之淡黃褐色蛹殼、蛹便及已成形之寄主成蟲、蛹或老熟幼蟲之遺體。

室溫 28°C、75% RH 飼育該蜂，完成1世代約需 11 天，計卵期 1.5 天，幼蟲期 5.5 天，蛹期4天。成蜂有取食寄主體液之習性。

該蜂在北部蔬菜田均可採得。

金小蜂（*Trichomalopsis* sp.）

該蜂屬金小蜂科（Pteromalidae）。爲單元寄生。成蜂羽化時在距繭之一端 0.5 mm 處咬一直

徑約 0.3 mm 之羽化孔外出。繭內留有該蜂之淡黃褐色蛹殼、蛹便及寄主遺體。

該蜂係於 63 年1月在龜山菜園採得之菜蛾小繭蜂繭羽化得雌、雄蜂各4隻。

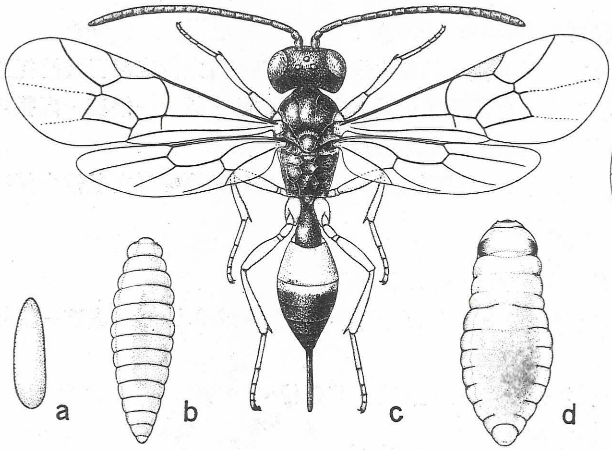

Fig. 2

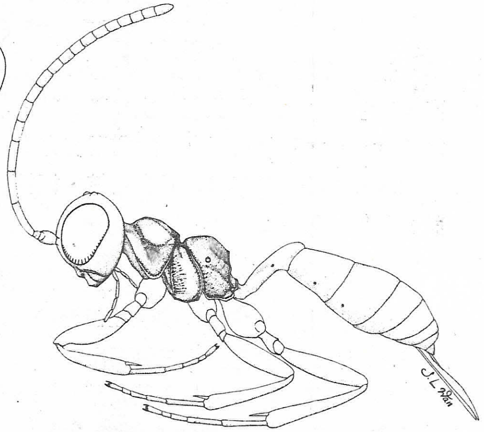

Fig. 3

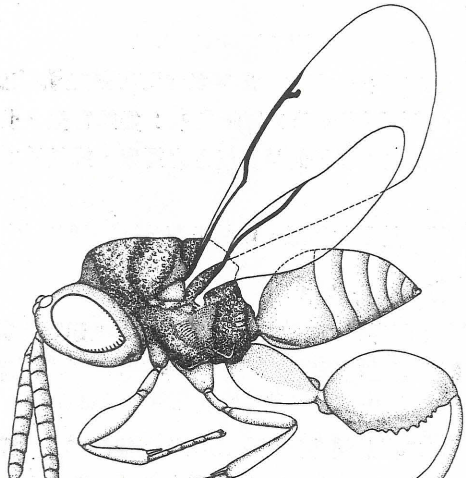

Fig. 4

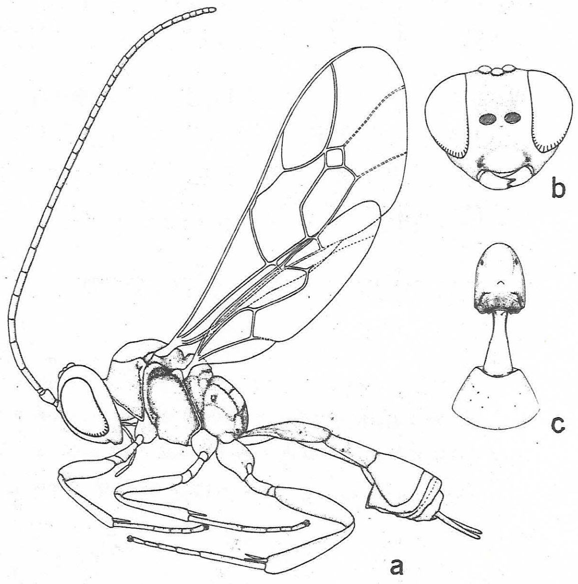

Fig. 5

圖2. 刺姬蜂：a. 卵，b. 老熟幼蟲，c. ♀，d. 前蛹。

圖3. 溝姬蜂，♀。

圖4. 大腿小蜂，♀。

圖5. 菱室姬蜂：a. ♀，b. 頭，c. 前伸腹節。

Fig. 2. *Diatora prodeniae*: a. egg, b. matured larva, c. adult ♀, d. prepupa.

Fig. 3. *Gelis* sp. ♀.

Fig. 4. *Brachymeria* sp. ♀.

Fig. 5. *Stictopisthus* sp.: a. adult ♀, b. head, c. propodeum.

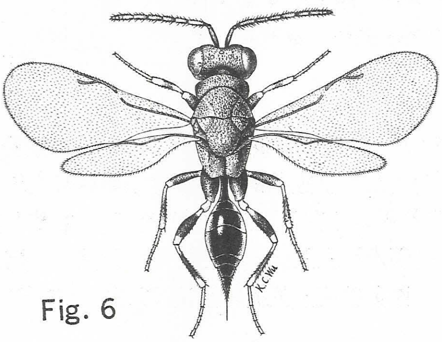

Fig. 6

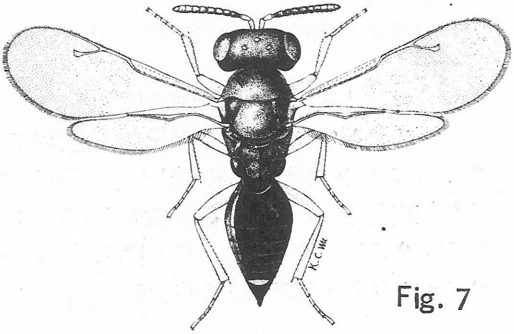

Fig. 7

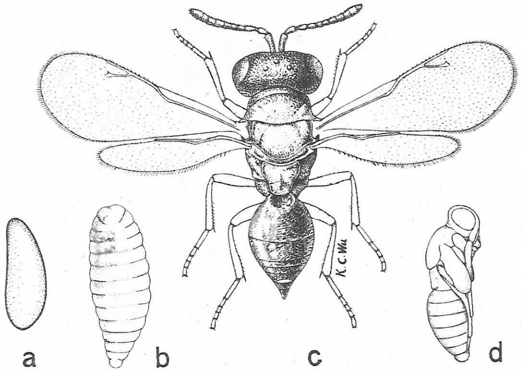

Fig. 8

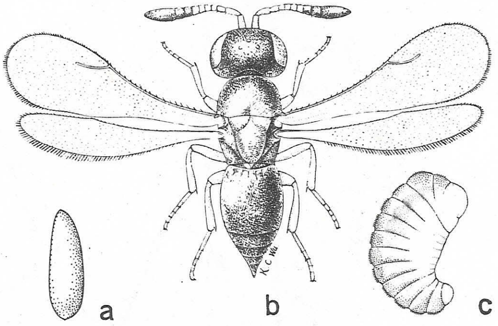

Fig. 9

圖6. 廣肩小蜂，♀。
圖7. 絨繭金小蜂，♀。
圖8. 素木金小蜂：a. 卵，b. 老熟幼蟲，c. ♀，d. 蛹。
圖9. 圓腹卵蜂：a. 卵，b. ♀，c. 老熟幼蟲。

Fig. 6. *Eurytoma* sp. ♀.
Fig. 7. *Trichomalopsis apantcloctena* ♀.
Fig. 8. *Trichomalopsis shirakii*: a. egg, b. matured larva, c. adult ♀, d. pupa.
Fig. 9. *Calliceras* sp.: a. egg, b. adult ♀, c. matured larva.

扁股小蜂 (*Elasmus* sp.)

該蜂屬扁股小蜂科（Elasmidae）。爲單元體外寄生。成蜂羽化時在繭之一端 0.5 mm 處咬一直徑約 0.6 mm 之羽化孔而出。繭內殘存該蜂之褐色蛹殼、灰褐色蛹便及已成形之寄主成蟲遺體。

該蜂係於 62 年 12 月在板橋菜園採得之菜蛾小繭蜂繭飼育得 1 隻雌蜂。

圓腹卵蜂 (*Calliceras* sp., 圖 9)

該蜂屬圓腹卵蜂科（Ceraphronidae）。雌蜂產卵時用觸角在寄主繭上敲打，選定位置後體軀與寄主繭平行，腹部末端下壓，觸角靜止不動。所產之卵略陷入寄主蛹體之觸角與體軀間。卵散生，故不易察覺。每隻寄主體上有 6 -10，最多 14 卵粒。

卵乳白色，長圓形，略彎曲，一端略尖。孵化後幼蟲在寄主體表爬行取食。老熟時，寄主已被消耗殆盡，遂在寄主繭內化蛹。老熟幼蟲體呈 "C"形，淡黃褐色，蛹淡黃白色。

成蜂羽化時在寄主繭之一端 0.24-0.34 mm 處咬一直徑約 0.34 mm 之羽化孔，1 隻隻成蜂相繼外出。寄主繭內留有該蜂之淡黃褐色蛹殼、黑褐色蛹便及乾癟之寄主皮囊。

室溫 28°C、75% RH 飼育該蜂，完成 1 世代約需 17 天。計卵期 2 天，幼蟲期 8 天，前蛹 2 天

，蛹期5天。

該蜂在北部蔬菜田均可採得。

菜蛾小繭蜂與其重複寄生蜂間之發生消長

由臺北網室菜園繁殖菜蛾小繭蜂之2次調查結果得知，第一批所得之蜂繭即有 3.1-5.8%被重複寄生，其後重複寄生率呈直線上升，15-30 天後約達 23%。此後網室菜園內出現之小繭蜂繭大增，因每天盡量予以收集，影響其重複寄生率之調查結果。又蜂繭之冷存日數長達 49-98 天，亦使其重複寄生率驟減，平均僅約8%。隨後因甘藍漸近採收期，小菜蛾發生量少，寄生蜂繭相對減少，因此未予大量採繭，而菜園內存留之部分蜂繭，其重複寄生率又漸見增高，最後約高達 52.9%（圖10)。

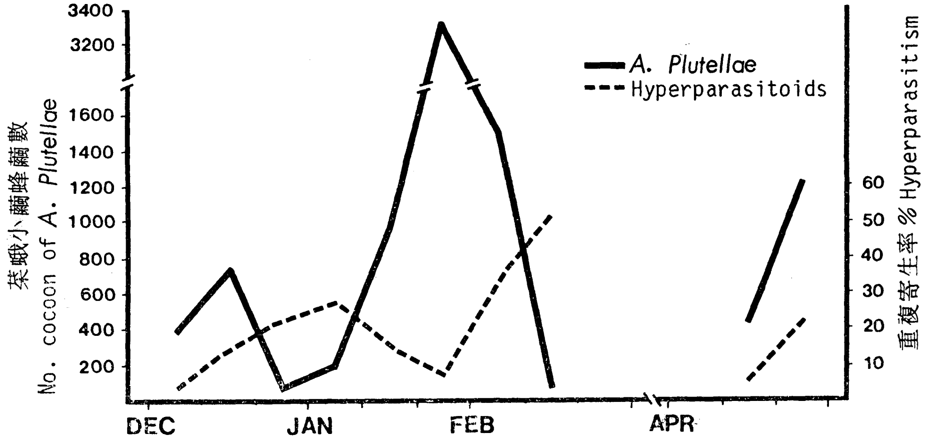

圖10. 臺北網室菜蛾小繭蜂與其重複寄生蜂之發生消長（1973-1974）

Fig. 10. Relationship between occurrence of *Apanteles plutellae* and its hyperparasitoids in Taipei screened house (1973-1974).

討　　論

寄生於植食性害蟲之寄生蜂類，一般稱爲寄生蜂（parasitoid）或第一次寄生蜂（primary parasitoid）。它們若被其它蜂類寄生時，後者常被稱爲重複寄生蜂（hyperparasitoid）或第二次寄生蜂（secondary parasitoid）[13]。重複寄生蜂之寄主範圍有時較爲廣泛，除寄生於多種寄生蜂外，也有寄生於害蟲而爲第一次寄生蜂。本文之菜蛾小繭蜂之重複寄生蜂即有此現象（表2）。

重複寄生現象對寄生蜂利用之影響，各學者看法不一。於進行某種害蟲生物防治時，常因重複寄生物之存在能够嚴重影響及寄生蜂對寄主害蟲之控制力，故學者對其採取隔絕政策，但 Doutt 與 DeBach 認爲此種見解僅爲1種邏輯觀念而已，尚未經過嚴格試驗或田間分析之印證[13]。DeBach 又云，重複寄生物在維持自然界昆蟲種與種間之平衡也居重要因素[13]。至於重複寄生蜂對菜蛾小繭蜂之寄生能力究竟有無嚴重之抑制影響，目前僅知其在小繭蜂出現之初期有 11-26 %之寄生率，發生中期約 30%，發生末期最高可達 52.9%。

Thompson 與 Herting、Simmonds 等氏報導寄生於 *Apanteles* 屬之寄生蜂約達 11 科 76 屬 280 種，但寄生於菜蛾小繭蜂之寄生蜂則未有記錄[15,18]。直至 1982 年 Kamijo 與 Grissell 兩氏才鑑定 *Trichomalopsis apantelotena* 爲菜蛾小繭蜂之重複寄生蜂[17]。國內方面亦僅朱耀沂提及該小繭蜂有重複寄生蜂，係屬小蜂總科，至於種名，寄生情形等均無記載[1]。故本文所述菜蛾小繭蜂之 10 種重複寄生蜂均屬本省新記錄。

由網室菜園繁殖菜蛾小繭蜂之結果，得知繁殖工作受天氣之影響甚大，又菜蛾小繭蜂出現田間之同時，其重複寄生蜂隨即發生，且因寄主蜂繭之陸續出現而增多，亦屬自然界中生物平衡之現象。但小繭蜂繭出現後因隨即予以收集，難免影響及小繭蜂之實際被寄生率，否則其重複寄生率當不止此數。

本試驗使用之大部分蜂繭均先經過冷藏並釋放於菜園後，再予收回而檢查其重複寄生情形。蜂繭經 7°C 冷存處理後，小繭蜂與其重複寄生蜂之羽化率均會受到影響，尤以重複寄生蜂爲甚。因寄生蜂冷藏之成敗與寄生蜂被冷藏當時之發育期有關。採收蜂繭時可確知小繭蜂已發育至老熟幼蟲或蛹，

表2. 菜蛾小繭蜂重複寄生蜂之寄主範圍
Table 2. Host range of hyperparasitoids of *Apanteles plutellae*

重複寄生蜂 Hyperparasitoid	寄生蜂 Parasitoid	寄生蜂之寄主 Host of parasitoid	文獻 Reference
Diatora prodeniae *Stictopisthus* sp.	*Apanteles cypris* *A. plutellae* *Microplitis tuberculifer* *Snellenius manilae*	*Cnaphalocrocis medinalis* *Plutella xylostella* *Spodoptera litura* *S. litura*	5, 11
Gelis sp. *Brachymeria* sp. *Trichomalopsis* sp. *Elasmus* sp. *Eurytoma* sp.	*Apanteles plutellae*	*Plutella xylostella*	
Calliceras sp.	*Apanteles plutellae* *Snellenius manilae*	*Plutella xylostella* *Spodoptera litura*	5
Trichomalopsis apanteloctena	*Apanteles baoris* *A. chilonis* *A. glomeratus* *A. hariyai* *A. parnarae* *A. plutellae* *A. ruficrus* *Apanteles* sp. *Meteorus* sp.	*Parnara gultata* *Chilo suppressalis* *Pieris rapae* *Leucania separata* *Parnara gultata* *Plutella xylostella* *Naranga aenescens* *Grapholitha molesta* *Sesamia inferens*	17
Trichomalopsis shirakii	*Apanteles plutellae* *Elachista* sp.	*Plutella xylostella* *Sasa* sp.	17
	Trichomalopsis apanteloctena	*Agromyza oryzae* *Cnaphalocrocis medinalis* *Hydrella griseola* *Naranga aenescens* *Oulema oryzae* *Oxya intricata* *Peropidas mathias* *Pieris brassicae* *P. rapae* *Vanessa polychloros*	15, 17
	Trichomalopsis shirakii	*Agromyza oryzae* *Hydrellia griseola* *Oulema oryzae* Syrphid	17

但卻無從得知繭內重複寄生蜂之發育期究爲卵、幼齡幼蟲、老熟幼蟲、前蛹或蛹。又冷存時日之長短將影響重複寄生蜂之存活率及其寄生率。如 62年 8 月 8 日於竹子湖採得 831 個菜蛾小繭蜂繭，其中224個蜂繭冷存26天取出，其重複寄生率爲40.6%，其餘607個蜂繭經冷存約 105 天，其重複寄生率僅爲17.3%。

寄生蜂之雌性成蟲常具有取食或捕食寄主（host feeding or host predatism）之習性，其成蜂利用產卵管刺破寄主昆蟲體壁取食其體液，有助於其體內卵之發育成熟，寄主則因被刺與食而致死[11,12,14,16]。DeBach 曾强調此種行爲在減低寄主害蟲棲羣密度之效果言之，實與產卵寄生行爲相同，

有時前者比後者更爲重要[12]。筆者等觀察刺姬蜂（*Diatora prodeniae*）與素木金小蜂（*Trichomalopsis shirakii*）之成蜂均有此習性，但其對寄主小繭蜂之致死率，則尚待進一步探討。

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The Hyperparasitoids of *Apanteles plutellae*, a Larval Parasitoid of Diamondback Moth in Taiwan[1]

by

Ching-chin Chien and Shui-chen Chiu[2]

Summary

Apanteles plutellae Kurdj., Braconidae, has been considered an effective larval parasitoid of the diamondback moth (DBM), *Plutellae xylostella* Linn. (Plutellidae) in Taiwan. It was mass-reared and released to vegetable growing areas viz. Shilin, Chupei, Hsilo, Yungchien, Nantyu, and Luchu in 1972 and 1973 for the biological control of DBM. This paper report the species and some biological information of the hyperparasitoids of *A. plutellae* in Taiwan.

A total of 10 species of hyperparasitoids of *Apanteles plutellae* were reared from 10,770 cocoons of *Apanteles plutellae*. They are *Diatora prodeniae*, *Gelis* sp., *Stictopisthus* sp. (Ichneumonidae); *Brachymeria* sp. (Chalcididae) ; *Eurytoma* sp. (Eurytomidae); *Trichomalopsis apanteloctena*, *T. shirakii*, *Trichomalopsis* sp. (Pteromalidae); *Elasmus* sp. (Elasmidae); and *Calliceras* sp. (Ceraphromidae). Three species of them, viz. *T. shirakii*, *Calliceras* sp. and *D. prodeniae* were successfully inoculated to the cocoons of *Apanteles plutellae* in laboratory. The females of *T. shirakii* and *D. prodeniae* were observed not only ovipositing to *A. plutellae* but also feeding upon host body-fluids and caused the death of host.

Percentage of hyperparasitism were recorded about 26.3% in the insecticides spraying fields, about 46.2% in the harvested fields, and about 3.1% during the initial period of *A. plutellae* cocoons appeared in the non-insecticides spraying screened house. The hyperparasitism in the screened house was high up to 53% after 75 days of *A. plutellae* cocoons were firstly occurred.

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Revision of the Taiwanese Species of *Alloea* Haliday (Hymenoptera: Braconidae, Alysiinae)[1]

Robert A. Wharton[2] and Liang-yih Chou[3]

Abstract: Four new species of *Alloea* (Hymenoptera: Braconidae) and a tabular summary of these species is presented. A key to the eight described species of *Alloea* is included, together with a dendrogram suggestion relationships among them.

The genus *Alloea* has been characterized primarily by the shape of the mandibles (Haliday, 1833; Wharton, 1980) and the wing venation (Fischer, 1966). In the collection of the Taiwan Agricultural Research Institute there are several individuals with typical *Alloea* mandibles, but which differ greatly in wing venation and antennal characters. Inclusion of these species in *Alloea* considerably broadens the definition of the genus, necessitating a redescription of *Alloea*. The terminology and measurements used in this paper follow Wharton (1977). Most of the type specimens are deposited in the collection of the Taiwan Agricultural Research Institute, and some of the paratypes are deposited in the Texas A&M University.

Genus **Alloea** Haliday

Type species: *Alloea contracta* Haliday, 1833; monobasic.

Head subcubical. Mandibles distinctly wider at base than at apex, with 3 distinct teeth; middle tooth very long, nearly equal in length to remainder of mandible, minutely serrate dorsally; teeth 1 and 3 greatly reduced; diagonal ridge present. First flagellomere distinctly longer than 2nd. Median flagellomeres of female expanded in some species and bearing dense tuft of short hairs ventrally; antenna equal to or slightly longer than body. Clypeus large, flat, approximately bell-shaped. Paraclypeal pits broad, extending at least half way to eye margin. Eyes bare. Malar space short to very long, with deep epistomal sulcus. Maxillary palps 5 or 6-segmented, labial palps 3 or 4-segmented. Pronotum without distinct median pit. Sternaulus extending beyond middle

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of mesopleuron; crenulate. Scutellum low, rounded, never with posterior spine. Metanotum with or without tall median flange. Propodeal spiracle minute. Fore wing venation complete, at least in female; stigma variable: long, narrow, often only weakly indicated basally and poorly differentiated from metacarpus; or greatly enlarged (especially in male), hemispherical; 1st radial segment arising near middle of most distinctly thickened portion of stigma; 2nd radial segment variable; shorter than, equal to, or longer than 1st cubital cross vein; 3rd radial segment straight to weakly recurved and ending at wing tip, or curving anteriorly and ending distinctly before wing tip; brachial cell closed at distal corner by 3rd discoideal segment; 2nd discoideal segment absent or very short, parallel vein arising at or above middle of brachial cell, interstitial in several species; recurrent vein antefurcal to postfurcal; postnervellus absent; radiella and cubitella very weak; basella often nealy equal in length to 2nd mediellan segment; 1st mediellan segment longer than 2nd. Abdomen strongly dorsal-ventrally depressed in both sexes; unsculptured beyond petiole. Ovipositor short to very short, with only extreme apex extending beyond tip of abdomen; ovipositor sheath hairs clustered near tip.

Diagnosis: The mandible dominated by a long, narrow tooth 2 and greatly reduced tooth 1 and 3 distinguishes *Alloea* from all other genera of the Alysiini. The broad, flat clypeus and long malar space (at least in some species) are similar to character states found in *Syncrasis*, and suggest a close relationship between the two.

Discussion: *Alloea* previously included only 4 species. Three (*A. bonessi* Fischer, *A. contracta* Haliday, and *A. lonchopterae* Fischer) were recorded from the western Palaearctic Region and one (*A. eleophila* Wharton) from the western Nearctic Region.

A preliminary analysis of relationship among *Alloea* species is illustrated in Fig 1, based largely on the data from Table 1. The newly described species from Taiwan exhibit a numbr of features either poorly developed or totally lacking in previously described forms. However, we feel it would be premature to propose supraspecific taxa at this time because of incongruencies in the existing data and the lack of material from the eastern Palaearctic and southeast Asian Regions.

In the *Alloea* species from Taiwan, there is considerable variation in the insertion of the recurrent and parallel veins and in the size of the 2nd cubital cell. This is in marked contrast to the relatively uniform states found in other *Alloea* species (Fischer, 1966; Wharton, 1980). Although *Alloea* is usually characterized by having the recurrent vein antefurcal and the parallel vein interstitial, neither condition is found in *A. lineata*, sp. n. As in *A. lineata*, *A. sparsa*, sp. n. has the parallel vein arising from the middle of the brachial cell. Although the latter feature is generally thought to be plesiomorphic, the position of these 2 species on the dendrogram indicates that reversals may have taken place. The 2nd cubital cell is somewhat elongate in *A. striata*, sp. n. and is considerably lengthened in *A. lineata*. Previously described *Alloea* species are characterized by a broad malar space and reduced eye size. In *A. ampla*, sp. n. and *A. striata*, however, the malar space is short. Based on the dendrogram, therefore, the malar region has become secondarily shortened in the *ampla-striata-lineata* lineage. It is hoped that description of additional *Alloea* species will clarify the trends noted here, especially for the

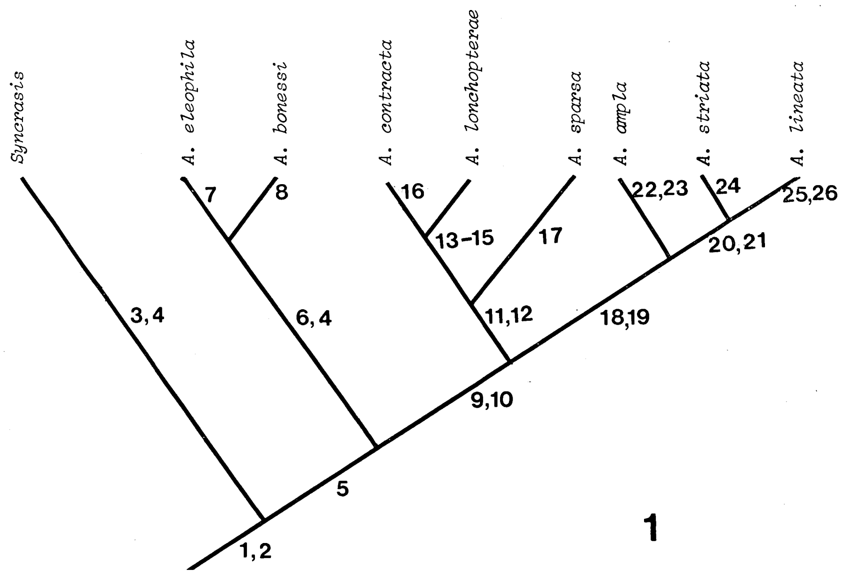

Fig. 1. Dendrogram showing relationships of *Alloea* species, based on shared, derived characteristics[4]. **1**, Bell-shaped or parabolic clypeus. **2**, Long malar space. **3**, Loss of 1st cubital segment. **4**, Reduction in number of palp segments. **5**, Mandible with elongate tooth 2. **6**, Stigma of fore wing broad, hemispherical, ending abruptly at metacarpus. **7**, Reduction in height of metanotal flange. **8**, Short 1st mediellan segment. **9**, Stigma tapering distally, merging gradually with metacarpus. **10**, Median flagellomeres expanded, at least moderately, and with brush of straight setae ventrally. **11**, r3 weakly curved. **12**, Mesonotum sparsely hairy. **13**, Mesonotal midpit extending forward as narrow groove to anterior margin of mesonotum. **14**, Mesopleuron striate dorsad of posterior end of sternaulus. **15**, Maxillary and labial palps short. **16**, Male brachypterous. **17**, Stigma nearly linear. **18**, Ventral brush of setae dense on median flagellomeres; subapical hairs lost. **19**, Reduced malar space. **20**, Loss of metanotal flange. **21**, Elongate r2 . **22**, Ovipositor elongate. **23**, Propodeal sculpture with characteristic crevice-like pattern. **24**, Loss of ventral brush on median flagellomeres with elongation of antenna. **25**, Mesonotal midpit lost or nearly so. **26**, Stigma linear.

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4. Material examined of the non-Taiwanese species. *Alloea contracata* Haliday: 1♀, Ireland, Co. Dublin, W. of Killeen, 8. I. 1945 (A. W. Stelfox). 1♂, The Netherlands, Meyendel, nr. Den Haag, 7. VI. 1973, Univ. Leiden. *Alloea bonessi* Fischer: 2♀, Paratypes, FR4 Lonchopt, *Alloea bonessi* ♀ det. Fischer. 1 ♀, Holotype, illegible code, *Alloea bonessi* ♀ det. Fischer (There are no locality labels on these 3 specimens). *Alloea eleophila* Wharton: 1♀, 1♂, Canada, Cherryville, 5. VI. 1975 (R. Wharton); 1♀, Paratype, 7.5mi. S. E. Princeton, 6. VI. 1975 (R. Wharton) . *Alloea lonchopterae* Fischer: 2♀, The Netherlands, Wijster(Dr.), opposite Biological Station, 10-17. VI. & 4-11. X. 1974 (C. van Achterberg).

Table 1. Comparison of Taiwanese *Alloea* species with *A. lonchoperae* Fischer

Characters	*lonchopterae*	*sparsa*	*ampla*	*striata*	*lineata*
Median flagellomeres	moderately expanded	not expanded	*greatly expanded	not expanded	moderately expanded
Malar space	long 0.3–0.4x eye height	*long, 0.4–0.5x eye height	**short, 0.11–0.18x eye height	short, 0.14x eye height	moderately long, 0.20–0.29x eye height
Occiput & Mesonotal hair	sparse, hairs only along notauli	*very sparse, hairs only along notauli	sparse, lateral mesonotal lobe bare	sparse, lateral mesonotal lobe bare	dense, uniformly hairy
Metanotal flange	tall	*tall	tall	**short, weakly developed	short, weakly developed
Propodeum	completely rugose	completely rugose, with carinae	rugose posteriorly, with fossae; base smooth laterally	completely rugose	largely smooth
Stigma	moderately broad at rl	nearly linear	moderately broad at rl	moderately broad at rl	*linear
Second radial segment	short, c. 1x cupul	short, 1.04–1.13x cuqul	short, 1.10–1.25x cupul	moderately long, 1.5x cuqul	*long, 2.2–2.4x cuqul
Recurrent vein	antefurcal	interstitial or weakly antefurcal	interstitial or weakly antefurcal	interstitial or weakly antefurcal	*strongly postfurcal
Parallel vein	interstitial	not interstitial	interstitial or nearly so	*interstitial	not interstitial
Med 2/Med 1	0.5–0.6	0.8	0.6	0.9–1.0	0.6–0.7

* Interpreted as most apomorphic state
**Possible reversal to plesiomorphic condition

Taiwanese species.

Flagellomere expansion and the ventral brush of straight setae on the median flagellomeres are features which provide evidence for a link between the Taiwanese fauna and that of the western Palaearctic. In *A. contracta*, *A. lonchopterae* and *A. lineata*, the median flagellomeres are more weakly expanded than in *A. ampla*, but all 3 have at least a weakly developed ventral brush. These features, confined to the female, are not evident in other *Alloea* species, although *A. striata* may have a trace of this brush. *Alloea contracta* and *A. lonchopterae* exhibit further relationship with the Taiwanese fauna through the shape of the stigma, which is less hemispherical than in other Holarctic species, and merges gradually with the metacarpus distally. The stigma is similarly shaped, though slightly more elongate, in both *A. striata*, and *A. ampla*. Further reduction of the stigma is evident in *A. sparsa*, and a discrete stigma is largely lost in *A. lineata*.

The position of both *A. sparsa* and *A. striata* on the dendrogram is in doubt. Character states 11 and 12 are weak, and *A. sparsa* may actually have more of a sister-group relationship to the remaining species delimited by character states 9 and 10. There is greater overall similarity between *A. striata* and *A. ampla* than between *A. striata* and *A. lineata*. However, the shared sculptural, setal, and wing venation pattern responsible for this similarity are believed to be plesiomorphic. Thus, more weight has been given to character states 20 and 21.

We have been unable to separate females of *A. lonchopterae* and *A. contracta* using the material available for examination. Further study is needed to determine the status of these 2 species.

Key to *Alloea* Species

1. Brachypterous, wings not extending to tip of abdomen, veins usually thickened, males .... *A. contracta* Haliday
- Macropterous, males and females 2
2. Stigma of fore wing broad, hemispherical to elliptical, discrete distally, ending abruptly at metacarpus (Fig. 2) 3
- Stigma linear to wedge-shaped, but always merging gradually with metacarpus distally (Figs. 10, 19, 28 & 37) 4

2

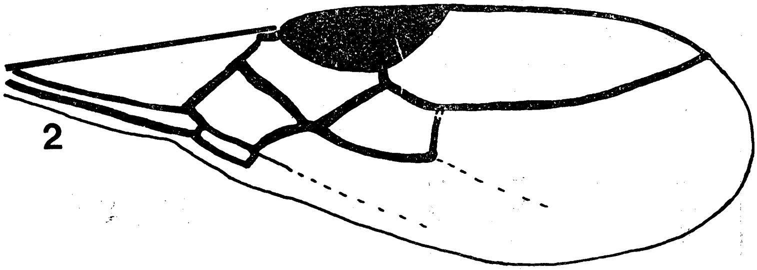

Fig. 2. Fore wing of *Alloea eleophila* Wharton, ♀.

3. Metanotum with tall median flange. Palaearctic··························*A. bonessi* Fischer
- Metanotum with low ridge. Nearctic··································*A. eleophila* Wharton
4. Recurrent vein distinctly postfurcal; 2nd cubital cell elongate, with 2nd radial segment at least twice length of 1st cubital cross-vein (Fig. 31) ···*A. lineata*, sp. n.
- Recurrent vein antefurcal to interstitial; 2nd cubital cell shorter, with 2nd radial segment at most 1.5 times longer than 1st cubital cross-vein (Figs. 10, 19 & 28) ···5
5. Malar space long, at lest 0.3 times eye height. Metanotal flange tall (Fig. 5) ·········6
- Malar space short, less than 0.2 times eye height. Metanotal flange variable···········8
6. Parallel vein arising from middle of brachial cell; stigma of fore wing nearly linear, barely perceptible (Fig. 10). Taiwan·······························*A. sparsa* sp. n.
- Parallel vein interstitial or nearly so; stigma broad, elliptical. Western Palaearctic ···7
7. Mesonotum about 1.6 times broader than apex of petiole···········*A. contracta* Haliday
- Mesonotum about 1.8 times broader than apex of petiole·········*A. lonchopterae* Fischer
8. Metanotal flange tall (Fig. 14). Median flagellomeres of female broadly expanded (Fig. 20) with dense brush of short hairs beneath························ *A. ampla* sp. n.
- Metanotal flange short, poorly developed (Fig. 23). Median flagellomeres of female neither expanded (Fig. 29) nor with dense brush of short hairs beneath··················· ···*A. striata* sp. n.

Alloea sparsa Wharton & Chou, **sp. n.**

(Figs. 3-11)

Female. Head: 1.7 times broader than long; 1.4 times broader than mesonotum. Head in dorsal view wider at eyes than at temples; eyes about 2.0-2.3 times longer than temples. Occiput very sparsely hairy above. Malar space long, 0.4-0.5 times as long as eye height. Face weakly convex; surface lightly hair-punctured; face about 1.3 times wider than high; clypeus large, nearly bell-shaped, base about twice as wide as mid-height. Mandible 1.8 times longer than apical width, 0.4 times length of head; surface weakly rugose between tooth 1 and 3, sparsely hairy at base. Antenna about 1.2 times longer than body; 24 or 25-segmented; 1st flagellomere 1.2-1.4 times longer than 2nd; middle flagellomeres not obviously expanded ventrally, segments 8-14 with sparse tuft of hairs. Maxillary palps longer than head.

Thorax: 1.5 times longer than high, 1.5 times higher than wide. Notauli present as well developed transverse sulci anteriorly, absent posteriorly. Midpit deep, moderately elongate, not extending anteriorly to middle of disc. Mesonotum sparsely hairy only along notaular lines. Prescutellar pit 4.0 times wider than long; with a midridge. Metanotum with tall flange. Propodeum completely rugose. Metapleuron rugose. Subalar area very sparsely hairy, nearly bare; remainder of disc smooth, polished, largely without hairs; posterior margin weakly crenulate, nearly smooth. Sternaulus crenulate, long, reaching middle coxa or not. Hind coxa slightly wrinkled above; hind femur about 5.6 times longer than wide.

Wing: Stigma linearly elongate, weakly broadened at 1st radial segment, barely

discrete distally, 7.8 times longer than broad; 3rd radial segment straight to weakly curved, ending just before wing tip; 2nd radial segment short, 1.7 times longer than 1st, 1.0-1.1 times longer than 1st cubital cross vein; 1st cubital cross vein straight, 2.3 times longer than 2nd cubital cross vein; recurrent vein interstitial to weakly antefurcal; nervulus postfurcal by about its own length; basal vein 1.4 times longer than 1st cubital segment; parallel vein arising from near middle of brachial cell. Fore wing about 3.1 times longer than thorax. Second segment of mediella 0.7-0.8 times as long as 1st, 2.0 times longer than basella.

Abdomen: Petiole 1.7-1.9 times longer than apical width; apex about 1.6 times wider than base; sparsely strigose. Ovipositor sheath with a dense apical tuft of hairs.

Color: Dark brown, maxillary and labial palps yellowish. Antenna and legs yellowish brown, 5th tarsi and claws darker. Wings hyaline, stigma and veins yellowish brown.

Length: Body, 1.9-2.1 mm; antenna, 2.2-2.4 mm; fore wing, 2.4-2.5 mm.

Male. Unknown.

Specimens examined: Holotype: ♀, Alishan 2400m, Chiayi, 12-16. VI. 1965 (T. Maa & K. S. Lin). Paratype: Anmashan 2275m, Taichung, 1♀, 6-9. VII. 1979 (L. Y. Chou). Additional specimens, Meifeng 2150m, Nantou, 2♂, 19-21. IV. 1983 (K. C. Chou & S. P. Huang). Tsuifeng 2300m, Nantou, 1♂, 9. V. 1984 (K. C. Chou & C. C. Pan).

Diagnosis: This species is characterized by the combination of reduced, nearly linear stigma, long malar space, short 2nd radial cell, and tall metanotal flange. It is less densely hairy on the mesonotum than other Taiwanese *Alloea* speciss.

The name of the new species refers to its sparsely hairy occiput and mesonotum. The 3 males listed above under "Specimens examined" have the mesonotum somewhat more densely hairy, with hairs scattered throughout the median lobe. They are thus included here with some hesitation.

Alloea ampla Wharton & Chou, **sp. n.**

(Figs. 12-20)

Female. Head: 1.6-1.7 times broader than long; 1.4 times broader than mesonotum. Head in dorsal view wider at eyes than at temples; eyes about 3.5-4.0 times longer than temles. Occiput sparsely hairy above. Malar space short, 0.11-0.18 times as long as eye height. Face weakly convex; granular-rugose medially, sparsely punctured laterally; face about 1.6 times wider than high; clypeus large, nearly bell-shaped, basal width about 1.6 times mid-height. Mandible 1.8 times longer than apical width, 0.4 times length of head; surface rugose, sparsely hairy at base. Antenna about 1.4 times longer than body; 28 or 29-segmented; lst flagellomere 1.5-1.7 times longer than 2nd. Flagellomeres 6-16 shorter and much broader, with dense tuft of hairs ventrally, segments 5 and 17 transitional. Maxillary palps longer than head.

Thorax: 1.5 times longer than high, 1.4-1.5 times higher than wide. Notauli present as well developed transverse sulci anteriorly, absent posteriorly. Midpit deep, elongate, extending anteriory to about middle of disc. Mesonotum densely hairy medially, lateral third bare on each side. Prescutellar pit 3.0 times wider than long; with a midridge.

Metanotum with tall flange. Propodeum rugose posteriorly, base smooth laterally; rugosities delineated by deep, convoluted fossae. Metapleuron rugose. Subalar area sparsely hairy; remainder of disc smooth, polished, without hairs; posterior margin deeply punctate throughout. Stenraulus crenulate, long, but not reaching middle coxa. Hind coxa rugulose; hind femur about 6.1 times longer than wide.

Wing: Stigma linearly elongate with weak expansion basally, 8.5 times longer than broad; 3rd radial segment straight or nearly so, ending at wing tip; 2nd radial segment short, 2.5 times longer than lst, 1.1-1.3 times longer than lst cubital cross vein; lst cubital cross vein straight, 2.0 times longer than 2nd; recurrent vein interstitial to weakly antefurcal; nervulus postfurcal by more than its length; basal vein 1.1 times longer than lst cubital segment; parallel vein interstitial or nearly so.Fore wing about 3.2 times longer than thorax. Second segment of mediella 0.5-0.6 times as long as lst, 1.3 times longer than basella.

Abdomen: Petiole 1.9-2.4 times longer than apical width; apex about 1.5 times wider than base; strigose. Ovipositor sheath with dense apical tuft of hairs.

Color: Dark brown, clypeus and mandible brown; maxillary and labial palps yellowish. antenna yellowish brown, especially basally. Wings hyaline, stigma and veins brown. Legs yellowish brown, 5th tarsi and claws darker.

L^ngth: Body, 2.3-2.5 mm; antenna, 3.1 mm; fore wing, 2.8-3.0 mm.

Male. Antenna 33-segmented; flagellomeres 6-16 not greatly expanded; lst flagellomere 1.4-1.5 times longer than 2nd. Stigma slightly broader basally than in female.

Specimens examined: Holotype: ♀, Anmashan 2275m, Taichung, 6-9. VII. 1979 (L. Y. Chou). Allotype: ♂, Tayuling 2560m, Hualien, 12-15. IX. 1980 (K. S. Lin & C. H. Wang). Paratypes: Tungpu 1200m, Nantou, 1♂, 13-16. XII. 1982 (K. C. Chou & C. C. Pan), & 2♀, 10-14. I. 1983 (K. C. Chou & S. P. Huang). Sungkang 2100m, Nantou, 1♀, 2♂, 6. VIII. 1984 (K. S. Lin), & 1♀, 2♂, 15-17. VIII. 1984 (K. C. Chou). Meifeng 2150m, Nantou, 1♀, 10. V., & 1 ♀, 15-22. V. 1979 (K. C. Chou), 1 ♀, 1♂, 22. V. 1982 (R. Wharton), 1♀, 15. VII. 1982 (S. C. Lin & C. N. Lin), 1♀, 19-21. IV. 1983 (K. C. Chou & S. P. Huang), 15♀, 3♂, 22-26. VI. 1983 (K. S. Lin & S. C. Lin), 3♂, 30. VII. 1983 (L. Y. Chou). Tsuifeng 2300m, Nantou, 1♂, 8. V. 1981 (K. S. Lin & S. C. Lin), 2♂, 23. V. 1982 (R. Wharton), & 1♀, 15-16. VIII. 1984 (K. C. Chou). Tayuling 2560m, Hualien, 1♂, 12-15. IX. 1980 (K. S. Lin & C. H. Wang), & 1♂, 6-9. IX. 1983 (L. Y. Chou & K. C. Chou).

Diagnosis: Females are separated from all other *Alloea* by the greatly enlarged median flagellomeres with exceptionally dense brush of ventral setae. As in *A. striata*, the malar space is short and the metanotal flange is reduced. However, the propodeum of *ampla* is characteristically sculptured with deep fossae.

The name of the new species refers to its flagellomeres greatly expanded at middle.

Alloea striata Wharton & Chou, **sp. n.**

(Figs. 21-29)

Female. Head: 1.6 times broader than long; 1.4-1.5 times broader than mesonotum.

Head in dorsal view slightly wider at eyes than at temples; eyes about 2.3-3.3 times longer than temples. Occiput sparsely hairy above. Malar space short, 0.14 times as long as eye height. Face weakly convex; densely punctate medially, sparsely punctate laterally; face about 1.4 times wider than high; clypeus large, nearly bell-shaped, basal width about 1.3 times mid-height. Mandible about twice longer than apical width, 0.4 times length of head; surface weakly rugose between tooth 1 and 3, moderately hairy at base. Antenna about 1.5 times longer than body; 34 or 35-segmented; lst flagellomere 1.3 times longer than 2nd; median flagellomeres not obviously expanded, without dense tuft of hairs ventrally. Maxillary palps longer than head.

Thorax: 1.4-1.5 times longer than high, 1.5-1.6 times higher than wide. Notauli present as well developed transverse sulci anteriorly, absent posteriorly. Midpit deep, elongate, extending anteriorly to about middle of disc. Mesonotum densely hairy medially, lateral third bare on each side. Prescutellar pit 3.3 times wider than long; with a midridge. Metanotal flange short, weakly developed. Propodeum almost completely rugose, rarely smooth or nearly so mid-basally. Metapleuron smooth to weakly rugulose. Subalar area densely hairy; remainder of disc smooth, polished, without hairs; posterior margin unsculptured or nearly so. Sternaulus crenulate, long, but not reaching middle coxa. Hind coxa smooth; hind femur about 6.0 times longer than wide.

Wing: Stigma moderately distinct and expanded medially, but blending imperceptibly with metacarpus distally, 6.9 times longer than broad; 3rd radial segment strongly recurved, ending at wing tip; 2nd radial segment moderately long, 5.3 times longer than lst, 1.5 times longer than lst cubital cross vein; lst cubital cross vein straight, 1.9 times longer than 2nd; recurrent vein interstitial to weakly antefurcal; nervulus postfurcal by a distance less than its own length; basal vein 1.3 times longer than lst cubital vein; parallel vein nearly interstitial. Fore wing about 3.2 times longer than thorax. Second segment of mediella subequal to lst, 2.1 times longer than basella.

Abdomen: Petiole 2.0 times longer than apical width; apex about 1.4 times wider than base; striate. Ovipositor sheath with dense apical tuft of hairs.

Color: Dark brown, mandible lighter, maxillary and labial palps yellowish. Antenna brown, scape, pedicel, and lst flagellomere basally yellowish. Wings hyaline, stigma and veins brownish. Legs yellowish brown, claws darker.

Length: Body, 2.5-2.8 mm; antenna, 3.5-4.0 mm; fore wing, 3.1-3.3 mm.

Male. Antenna 38 or 39-segmented; lst flagellomere 1.5 times longer than 2nd.

Specimens examined: Holotype: ♀, Meifeng 2150m, Nantou, 15. VII. 1982 (S. C. Lin & C. N. Lin). Allotype: ♂, Meifeng 2150m, Nantou, 22. V. 1982 (L. Y. Chou). Paratypes: Meifeng 2150m, Nantou, 1♀, 5-9. X. 1980 (C. C. Chen & C. C. Chien), 2♂, 22. V. 1982 (R. Wharton), 1♀, 15. VII. 1982 (S. C. Lin & C. N. Lin). 4♂, 19-21. IV. 1983 (K. C. Chou & S. P. Huang), 8♀, 2♂, 22-26. VI. 1983 (K. S. Lin & S. C. Lin), 1 ♂, 30. VII. 1983 (L. Y. Chou), & 1♀, 3♂, 8-11. V. 1984 (K. C. Chou & C. C. Pan). Tsuifeng 2300m, Nantou, 1♂, V. 1984 (K. S. Lin & K. C. Chou).

Diagnosis: This species is characterized by the greatly elongate antenna, bearing at

least 5 more flagellomeres than the comparably-sized *A. ampla*. Similarly to *ampla*, *striata* has a short malar space and reduced metanotal flange. The median flagellomeres are not noticeably expanded in *A. striata*.

The name of the new species refers to its striate petiole.

Alloea lineata Wharton & Chou, **sp. n.**

(Figs. 30-38)

Female. Head: 1.3-1.4 times broader than long; 1.3-1.4 times broader than mesonotum. Head in dorsal view barely wider at eyes than at temples; eyes about twice as long as temples. Occiput somewhat densely hairy above. Malar space moderately long, 0.20-0.29 times as long as eye height. Face weakly convex; surface densely hair-punctured; face about 1.1 times wider than high; clypeus large, nearly bell-shaped, base about twice as wide as mid-height. Mandible about twice longer than apical width, 0.4 times length of head; surface smooth, sparsely hairy at base. Antenna about 1.3 times longer than body; 23-27-segmented; lst flagellomere 1.2-1.3 times longer than 2nd; flagellomeres 9 to 12 moderately expanded, with dense tuft of hairs ventrally, segments 7 to 8 and 13 to 14 transitional. Maxillary palps longer than head.

Thorax: 1.3-1.4 times longer than high, 1.6 times higher than wide. Notauli present as well developed transverse sulci anteriorly, absent posteriorly. Midpit absent, or present posteriorly only as a very narrow, shallow crease. Mesonotum uniformly hairy, without bare patches laterally. Prescutellar pit 3.8 times wider than long; with a midridge. Metanotal flange short, weakly developed. Propodeum largely smooth with several well-defined carinae. Metapleuron rugose ventrally. Subalar area densely hairy; remainder of disc smooth, polished, without hairs; posterior margin unsculptured. Sternaulus crenulate, long, but not reaching middle coxa. Hind coxa smooth; hind femur about 6.9 times longer than wide.

Wing: Stigma greatly reduced, linear, blending imperceptibly with metacarpus, 7.5 times longer than broad; 3rd radial segment weakly recurved, nearly straight, ending at wing tip; 2nd radial segment very long, 4.0-4.5 times longer than lst, 2.2-2.4 times longer than lst cubital cross vein; lst cubital cross vein straight, 1.1-1.5 times longer than 2nd; recurrent vein strongly postfurcal; nervulus barely postfurcal; basal vein 1.7 times longer than lst cubital segment; parallel vein arising from near middle of brachial cell. Fore wing about 3.6 times longer than thorax. Second segment of mediella 0.6-0.7 times longer than lst, 2.0 times longer than basella.

Abdomen: Petiole 1.3-1.5 times longer than apical width; apex about 1.4 times wider than base; with some longitudinal carinae. Ovipositor sheath with sparse tuft of hairs.

Color: Brown, mandible lighter, maxillary and labial palps yellowish. Antenna yellowish brown. Wings hyaline, stigma and veins brownish. Legs yellowish brown, tarsi and claws darker.

Length: Body, 1.8-2.0 mm; antenna, 2.2-2.6 mm; fore wing, 2.4-2.7 mm.

Male. Antenna 26-28-segmented; flagellomeres not expanded at middle; lst flagello-

mere 1.4 times longer than 2nd.

Specimens examined: Holotype: ♀, Meifeng 2150m, Nantou, 5-9. X. 1980 (C. C. Chen & C. C. Chien). Allotype: ♂, collecting data same as holotype. Paratypes: Taipingshan 1950m, 1♂, 26-28. VII. 1983 (L. Y. Chou). Tungpu 1200m, Nantou, 1♂, 18-23. XI. 1981 (T. Lin & W. S. Tang), 1♀. 22-25. XI. 1982 (K. C. Chou & S. P. Huang), 4♂, 13-16. XII. 1982 (K. C. Chou & C. C. Pan), & 1♂, 10-14. I. 1933 (K. C. Chou & S. P. Huang). Meifeng 2150m, Nantou, 1♀, 5-9. X. 1980 (C. C. Chen & C. C. Chien), 1♀, 3♂, 22. V. 1982 (R. Wharton), 1♂, 31. VIII. -2. IX. 1982(L. Y. Chou & K. C. Chou), 1♂, 19-21. IV. 1983 (K. C. Chou & S. P. Huang), & 2♂, 22-26. VI. 1983 (K. S. Lin & S. C. Lin). Tsuifeng 2300m, Nantou, 1♀, 25-27. VI. 1981 (K. S. Lin & W. S. Tang), 3♂, 23. V. 1982 (L. Y. Chou), 1♂, 16. VII. 1982 (S. C. Lin & C. N. Lin), 1♂, 1-3. IX. 1982 (L. Y. Chou & K. C. Chou), 1♂, 23-25. VI. 1983 (K. S. Lin & S. C. Lin), 1♀, IV., 1♀, 3♂, V., & 1♀, 1♂, VII. 1984(K. S. Lin & K. C. Chou), 2♂, 15-16. VIII. 1984 (K. C. Chou), & 1♀, 1♂, 12-14. IX. 1934 (K. S. Lin & S. C. Lin). Tayuling 2560m, Hualien, 2♀, 2♂, 6-9. IX. 1983 (L. Y. Chou & K. C. Chou).

Diagnosis: This species is readily separated from all other described *Alloea* by the postfurcal recurrent vein and the linear stigma. In addition, the 2nd cubital cell is very elongate, and the parallel vein is not interstitial.

The name of the new species refers to its linearly elongate stigma.

Acknowledgements

We are most grateful to Dr. M. Fischer, Naturhistorishes Museum, Wien, for the loan of type material and other specimens; and to Drs. Fischer and C. van Achterberg, Rijksmuseum van Natuurlijke Historie, Lieden, for kindly allowing the senior author to examine specimens in their collection.

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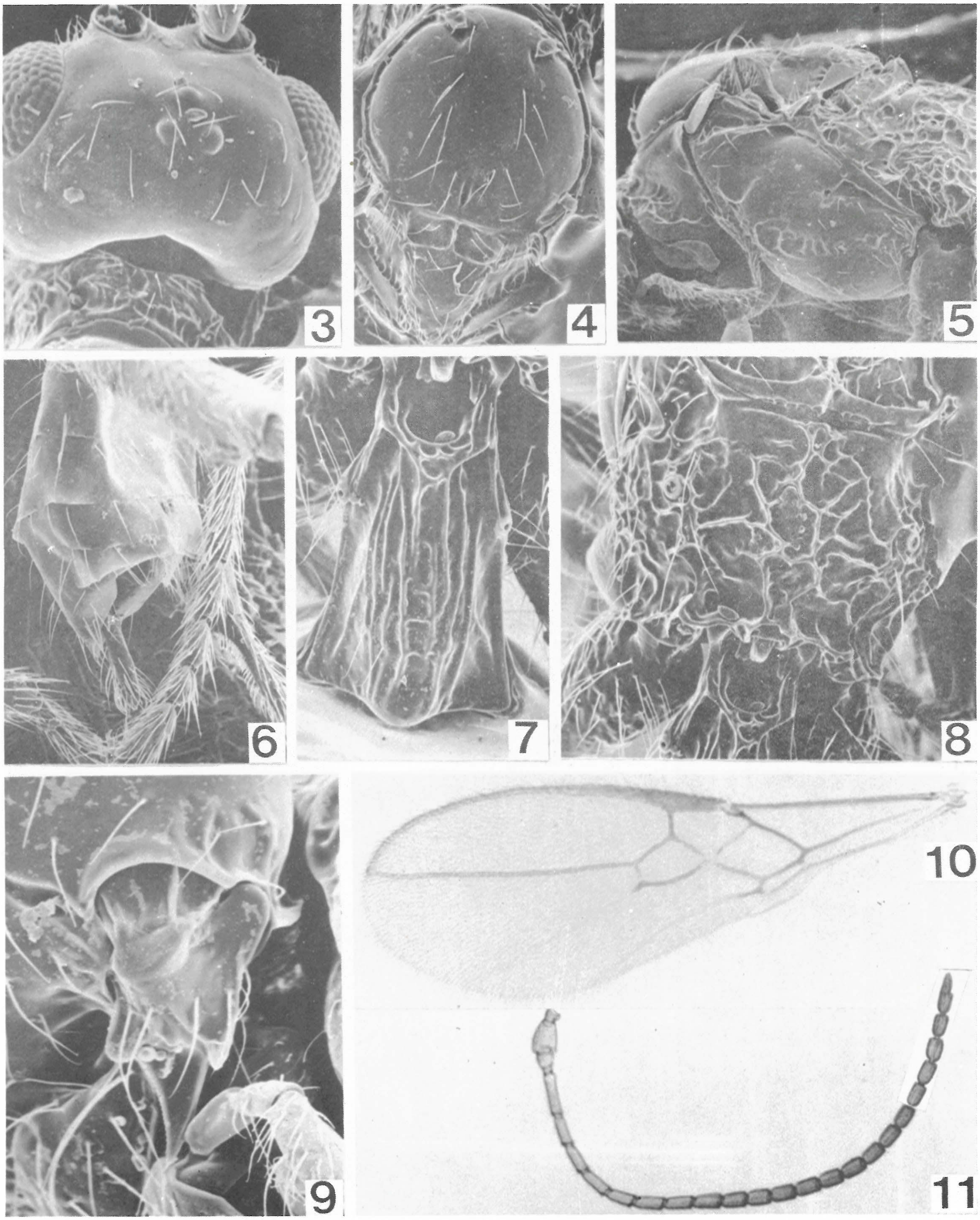
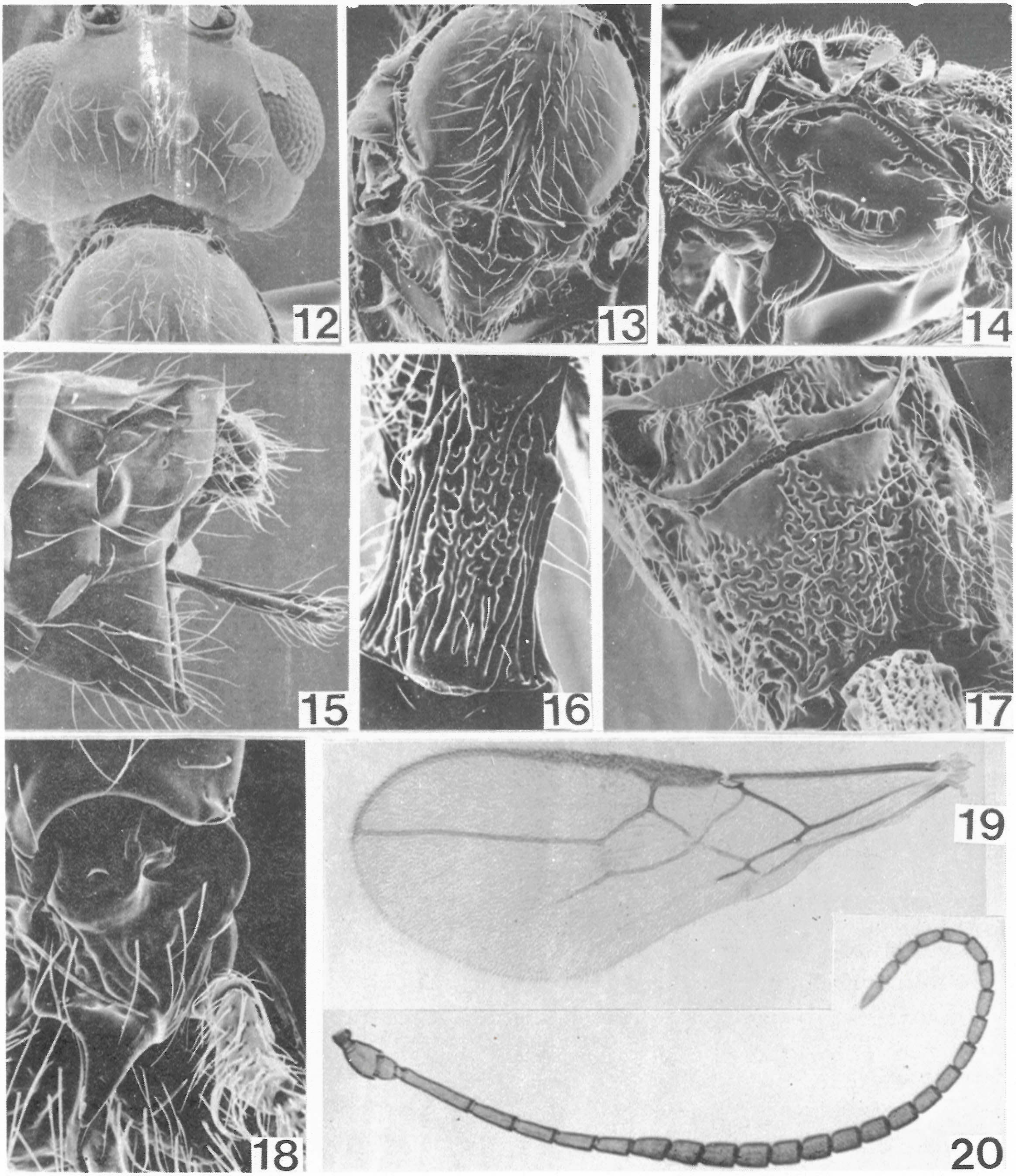
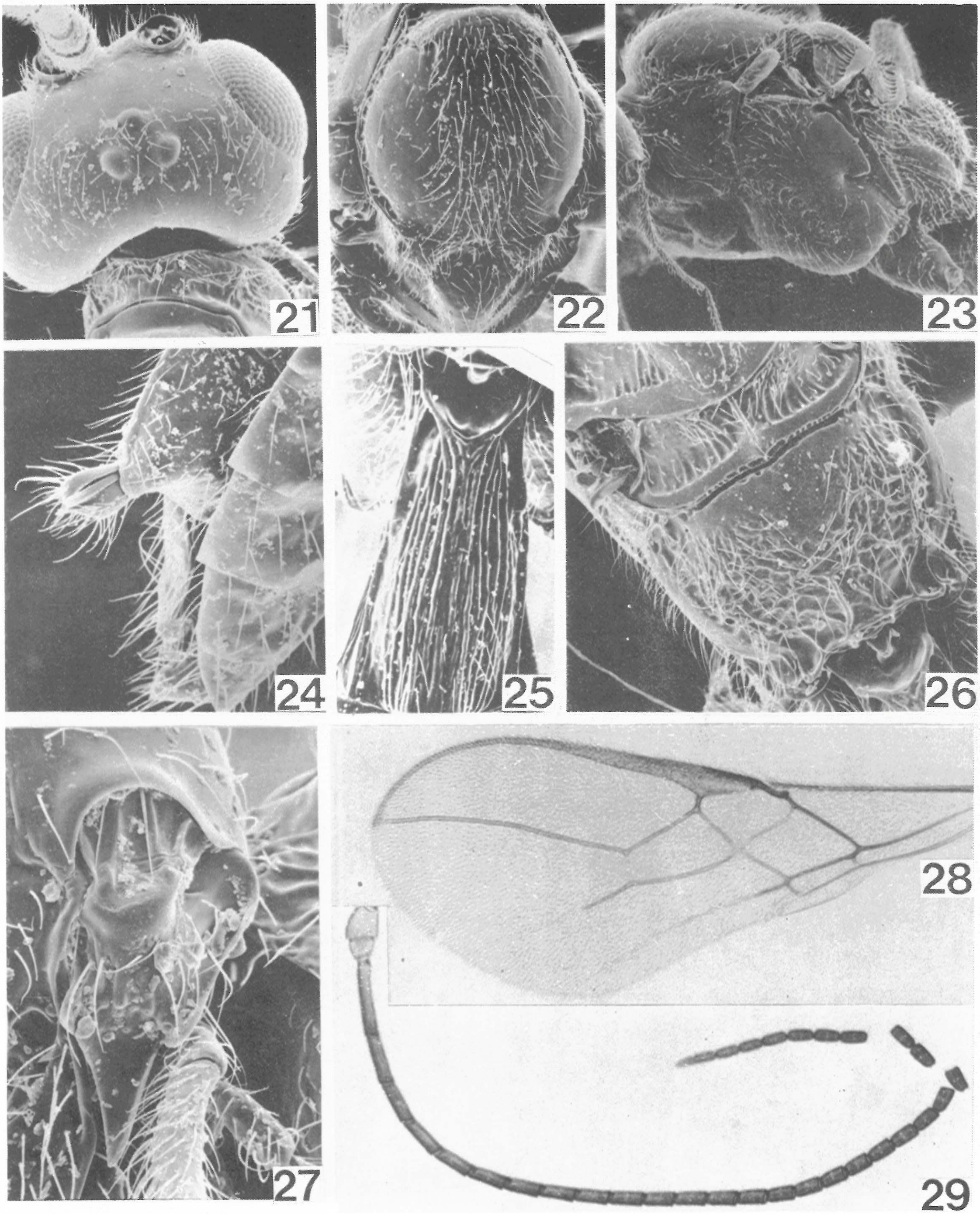


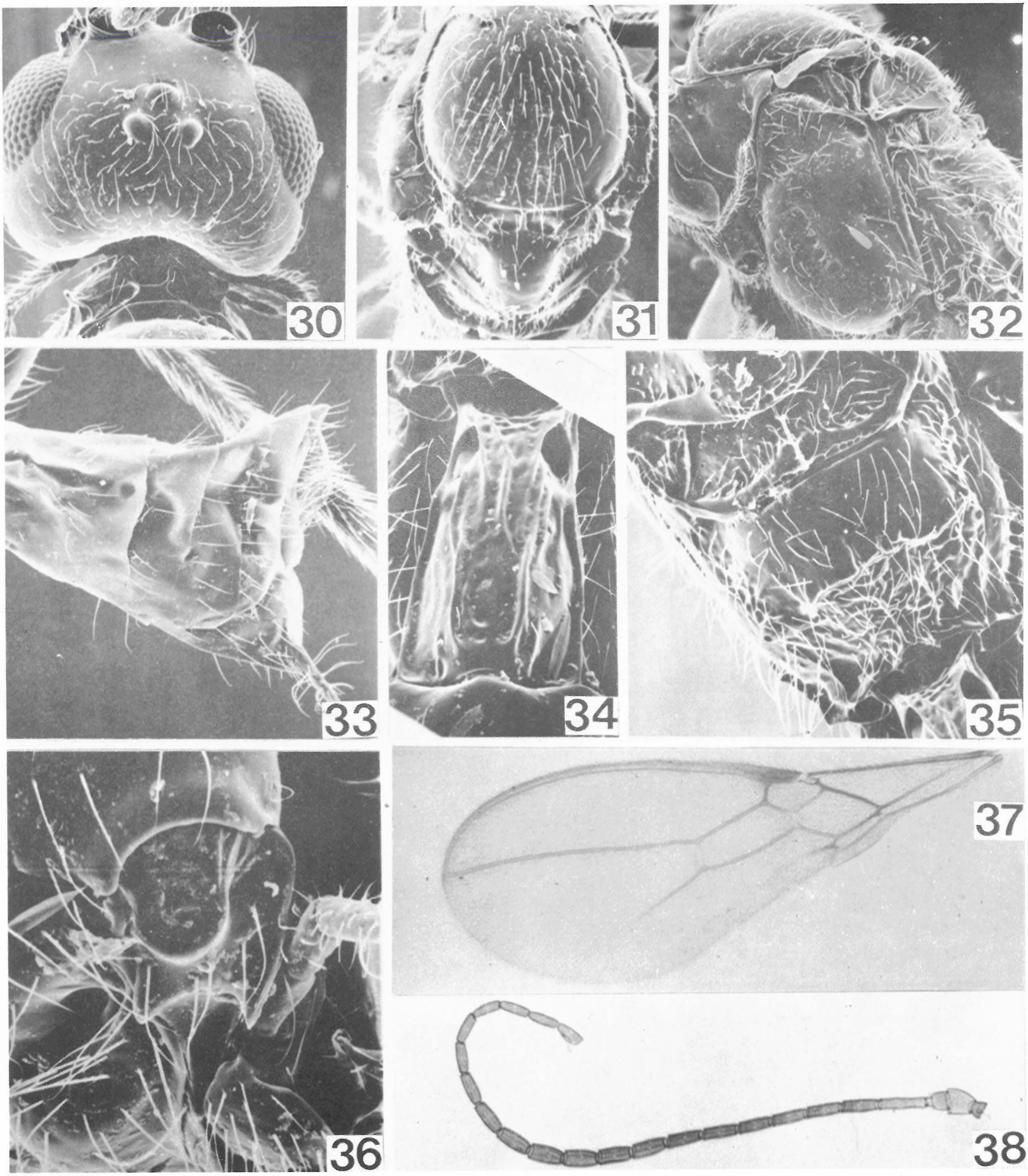
Figs. 3-11, *Alloea sparsa*, sp. n., female: 3, dorsal view of head; 4, mesonotum; 5, lateral view of thorax; 6, lateral view of apical part of abdomen; 7, dorsal view of petiole; 8, propodeum; 9, mandible; 10, fore wing; 11, antenna (Not in the same scale).



Figs. 12-20, *Alloea ampla*, sp. n., female: 12, dorsal view of head; 13, mesonotum; 14, lateral view of thorax; 15, lateral view of apical part of abdomen; 16, dorsal view of petiole; 17, propodeum; 18, mandible; 19, fore wing ; 20, antenna (Not in the same scale).



Figs. 21-29, *Alloea striata*, sp. n., female: 21, dorsal view of head; 22, mesonotum; 23, lateral view of thorax; 24, lateral view of apical part of abdomen; 25, dorsal view of petiole; 26, propodeum; 27, mandible; 28, fore wing ; 29, antenna (Not in the same scale).



Figs. 30–38, *Alloea lineata*, sp. n., female: 30, dorsal view of head; 31, mesonotum; 32, lateral view of thorax; 33, lateral view of apical part of abdomen; 34, dorsal view of petiole; 35, propodeum; 36, mandible; 37, fore wing; 38, antenna (Not in the same scale).

臺灣長齒開顎繭蜂屬之分類

(膜翅目：小繭蜂科，開顎繭蜂亞科)[1]

Robert A. Wharton[2] 周 樑 鎰[3]

摘要：本文描述臺灣產長齒開顎繭蜂屬（*Alloea*）4 新種， 另外輔以圖與表加以說明比較。且以檢索表區分全世界已知 8 種之長齒開顎繭蜂屬，並以系譜圖探討其可能之相互關係。

1. 臺灣省農業試驗所 研究報告第 1238 號，及美國德州農業實驗站 TA 20224 號。
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